John L. Malay's
Book
June 16th 1837
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John L. Malays

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Jan 16th 1833

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John Oliver Book

A SURVEY

OF THE

WISDOM OF GOD IN THE CREATION:

OR

A COMPENDIUM OF

NATURAL PHILOSOPHY.

CONTAINING

AN ABRIDGMENT OF THAT BEAUTIFUL WORK,

THE CONTEMPLATION OF NATURE.

BY MR. BONNET, OF GENEVA.

ALSO,

AN EXTRACT

FROM MR. DEUTEN'S "INQUIRY INTO THE ORIGIN OF THE "DISCOVERIES ATTRIBUTED TO THE ANCIENTS."

In Two Volumes.

BY JOHN WESLEY, A. M.

Vol. I.

Third American Edition, Revised and Enlarged; with Notes,

BY B. MAYO.

NEW-YORK:

PUBLISHED BY N. BANGS AND T. MASON, FOR THE METHODIST EPISCOPAL CHURCH.

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DISTRICT OF PENNSYLVANIA, TO WIT.

L. S.

BE IT REMEMBERED, That on the twenty-second day of March in the fortieth year of the Independence of the United States of America, A. D. 1816. JONATHAN POUNDER, of the said district, hath deposited in this office the title of a book, the right whereof he claims as proprietor, in the words following, to wit:

"A Survey of the wisdom of God in the creation, or a compendium of Natura Philosophy, containing an abridgment of that beautiful work, "The Contem plation of Nature." By Mr. Bonnet, of Geneva. Also an extract from Mr. Deuten's "Inquiry into the origin of the discoveries attributed to the Ancients." In two volumes. By John Wesley, A. M. second American edition revised, and enlarged; with Notes, by B. Mayo.

In Conformity to the Act of Congress of the United States, entitled, "An Act for the encouragement of Learning, by securing the Copies of Maps, Charts, and Books, to the Authors and Proprietors of such Copies, during the Times therein mentioned."—And also to the Act entitled "An Act supplementary to An Act, entitled "An Act for the encouragement of Learning, by securing the Copies of Maps, Charts and Books, to the Authors and Proprietors of such Copies during the Times therein mentioned," and extending the Benefits thereof to the Arts of designing, engraving, and etching historical and other Prints."

D. CALDWELL,

Clerk of the district of Pennsylvania.

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Advertisement to the Present Edition.

ON presenting the following pages to the public it was deemed proper to premise a few remarks on the present edition.

The very great celebrity of the author renders any eulogium unnecessary; being equally accredited by his friends and his enemies, for a rigid adherence to truth, and a strict observance of facts. For learning and ability, his claims to the palm of high distinction remain undisputed: and for piety, morality, indefatigable and useful labours, during a long life, a round of ages scarce presents a parallel. During half a century devoted to incessant travelling, he had greater opportunities for observation, and local information, than scarce any other man can boast. These considerations demand a more than ordinary respect, for the details and observations of the author.

The title of the work is expressive of the design. It was not intended as a rudimental work, whose pages should be occupied with problems, demonstrations, and corollories, which, as the author expresses it, are so far from answering any useful purpose to most readers, that they only serve to perplex and bewilder, and prevent the acquisition of that portion of useful knowledge, which every reader is competent to the attainment of.

It was thought proper to make such alterations in the work, as were calculated to remedy any absolete parts, or to convey information of any recent improvement, to adapt it to the present attainments in science, and render it as intelligible as possible, even to the meanest capacity.

The work has been considerably enlarged, by the addition of the notes. The chapters treating on astronomy, which were selections of various and widely different theories and opinions, counteracting each other, it was thought proper to supply, by a more concordant arrangement; many of the ancient opinions in astronomy having become obsolete, and the chapters, alluded to, abounding in those opinions, it is presumed, the substituted chapters, will be considered as an improvement to the work.

Philadelphia, March 25, 1816.

PREFACE.

I HAVE long desired to see such a compendium of natural philosophy, as was not too diffuse, not expressed in many words, but comprised in so moderate a compass, as not to require any large expense, either of time or money; not maimed or imperfect, but containing the heads of whatever (after all our discoveries) is known with any degree of certainty, either with regard to the earth or the heavens. And this I wanted to see in the plainest dress; simply and nakedly exprest, in the most clear, easy, and intelligible manner, that the nature of things would allow: particularly free from all the jargon of mathematics, which is mere Heathen Greek to common readers. At the same time I wished to see this short, full, plain account of the visible creation, directed to its right end: not barely to entertain an idle, barren curiosity; but to display the invisible things of God, his power, wisdom and goodness.

But I cannot find such a treatise as this in any modern, any more than ancient language. And I am certain there is none such in the English tongue. What comes nearest to it, of any thing I have seen, is Mr. Ray's "Wisdom of God in the Creation;" Dr. Derham's Physico and Astro-Theology;" Niewentyt's "Religious Philosopher," Mather's "Christian Philosopher," and "Nature Delineated." But none of these, single, answers the design. And *who* will be at the pains to extract the substance of them all, and add the later discoveries, of which they had little knowledge, and therefore could take but little notice? This is a desideratum still; and one that a lover of mankind would rejoice to see even tolerably supplied.

I am thoroughly sensible, there are many who have far more ability, as well as leisure, for such a work, than me. But as none of them undertake it, I have myself made some little attempt in the ensuing volumes. Herein following Mr. Derham's plan, I divide the work into text and notes.* The text is in great measure translated from the Latin work of John Francis Buddœus, the late celebrated professor of philosophy, in the university of Jena, in Germany. But I have found occasion to retrench, enlarge, or alter every chapter, and almost every section. So that it is now, I believe, not only pure, containing nothing false or uncertain; but as full as any tract can be expected to be, which is comprised in so narrow a compass: and likewise plan, clear, and intelligible to one of a tolerable understanding. The notes contain the sum of what is most valuable, in the above named writers: to which are added the choicest discoveries both of our own, and of the foreign societies. These likewise, I trust, are as plain and clear, as the nature of the things spoken will allow: although some of them, I know, will not be understood by an unlearned, or inattentive reader.

Mean time I must apprise the reader, that I have sometimes a little digressed, by reciting both uncommon appearances of nature, and uncommon instances of art: and yet this is not properly a digression, from the main design I have in view. For surely in these appearances also, the wisdom of God is displayed: even that manifold wisdom, which is able to answer the same ends by so various means. And those surprising instances of art do likewise reflect glory upon Him, whose spirit in man giveth that wisdom, whose inspiration teacheth understanding.

* So it was in the first edition. Many of these are now taken into the text.

It will be easily observed, that I endeavour throughout, not to *account for* things; but only to *describe* them. I undertake barely to set down what appears in nature; not the cause of those appearances. The facts lie within the reach of our senses and understanding; the causes are more remote. That things are so, we know with certainty: but why they are so, we know not. In many cases we cannot know; and the more we inquire, the more we are perplexed and entangled. God "hath so done his works," that we may admire and adore: but "we cannot search them out to perfection."

And does not this open to us another prospect? although one we do not care to dwell upon. Does not the same survey of the creation, which shews us the wisdom of God, shew the astonishing ignorance, and short-sightedness of man? For when we have finished our survey, what do we know? How inconceivably little! Is not every thinking man constrained to cry out, "and is this all? Do all the boasted discoveries of so enlightened an age, amount to no more than this?" Vain man would be wise! But with how little success does he attempt it? How small a part do we know even of the things that encompass us on every side? I mean as to the very fact: for as to the reasons of almost every thing which we see, hear, or feel, after all our researches and disquisitions, they are hid in impenetrable darkness.

I trust, therefore, the following sheets may, in some degree, answer both these important purposes. It may be a means, on the one hand, of humbling the pride of man, by showing that he is surrounded on every side, with things which he can no more account for, than for immensity or eternity: and it may serve on the other, to display the amazing power, wisdom, and goodness of the great Creator; to warm our hearts, and to fill our mouths with wonder love and praise!

JOHN WESLEY.

March 25th, 1775.

I HAD finished the additions which I designed to make to the System of Natural Philosophy, before I saw Dr. Goldsmith's "History of the Earth and Animated Nature." I had not read over the first volume of this, when I almost repented of having wrote any thing on the head. It seemed to me, that had he published this but a few years sooner, my design would have been quite superseded: since the subject had fallen into the hands of one, who had both greater abilities, and more leisure for the work. It cannot be denied, that he is a fine writer. He was a person of strong judgment, of a lively imagination, and a master of language, both of the beauty and strength of the English tongue.

Yet I could not altogether approve of this, that it seemed the design of the author, to say all he *could* upon every article; rather than all he *should* say. Hence arose his numerous and large digressions, making no inconsiderable part of his work. Hence his minute description of cows, horses, dogs; of cocks, hens, and pigeons, and of abundance of animals equally known to every man, woman and child: descriptions that are of little or no use, and no more entertaining than useful: at least useful only to the bookseller, by swelling the bulk, and consequently the price of his book.

Indeed this, the price of it, must ever remain a weighty objection to many readers. They cannot afford to purchase eight volumes, at six or seven shillings a volume. Ten or fifteen shillings they may possibly afford, for five or six smaller volumes; especially when they contain all that is curious, or useful, in the far more costly work. Nay I hope considerably more than all; as I have consulted abundance of authors, and taken abundance of passages from them, whom, I apprehend, the doctor had not seen.

I have another objection to this ingenious book: I doubt, some parts of it are not true. The author indeed has corrected many vulgar errors; but has, I fear, adopted others in their place. Many times he exposes the credulity of other writers: but does he not sometimes fall under the same imputation? As where he terms presumption, to deny the existence of Bishop Pontopedan's cracken, and the sea-serpent: the one a mile across, the other raising himself out of the water, higher than the main mast of a man of war! Could one who made the least scruple of rejecting these gross absurdities, accuse other writers of credulity?

Mean time the accounts which he has given of many animals, being taken from the best, and latest authorities, are both more accurate, and more to be depended on, than any which had been published before. Many of these I have inserted in their places (only contracting thirty or forty pages into four or five;) often in the room of those, which were less accurate, and probably, less authentic: as also several of his beautiful remarks, such as directly tended to illustrate that great truth, "O Lord, how manifold are thy works! In wisdom hast thou made them all!"

Preface to the Present Edition.

PHILOSOPHY has been cultivated as a science from the earliest ages. Most nations boast their antiquity therein. It has been deemed, and very justly, the most important and interesting branch of knowledge, to know ourselves, and the things with which we are immediately connected. The attainment of this knowledge in its fullest extent is impossible in consequence of our limited capacities; but though the connecting links of nature are innumerable, and her chain universal, and infinitely extended beyond our mortal grasp, it is not therefore a reason, that we should fold our hands, and hide our talent in the earth: but it is equally our duty and our privilege, to prosecute every laudable inquiry, and attain to that various knowledge which Providence has placed within our reach.

The importance of an acquaintance with this branch of literature, has been amply attested by the example and commendation of the wisest and best men in all ages and countries; the most eminent characters having distinguished themselves by their devotions thereto. In short the history of the science, and the biography of eminent characters furnish its best eulogium. A Newton, a Franklin, a Lavosier, a Kepler, and numerous others, names sacred on the records of fame, are durable monuments of the high utility of the science.

Besides its universal subservience to the ordinary necessities of mankind, and the dignity and lustre which it attaches to individuals; it is more conspicuously characterized, it adds lustre, rank, and dignity to nations, it has a constant tendency to exalt them above the savage state; to emancipate them from the chains of despotism, and snatch them from the jaws of superstition. Philosophy is the handmaid of benevolence, and the guardian of human rights; it nurtures freedom in the cradle of liberty, and heroism in the lap of truth: it widely extends the sphere of human action, and makes a man a judge of his own affairs.

Philosophy is productive of still more exalted benefits to man individually, by the improvement of the mind. It qualifies the mind for the exercise of its rational powers, it furnishes abundant matter for contemplation; it points out the true source of human felicity, in the well ordered mind, and marks it as vain, to look for felicity abroad, if the mind itself is not attuned to tranquility and enjoyment.

The efforts to improve the various branches of natural philosophy within the last century have been numerous and successful; it required some time for observation before the requisite data could be discovered, to direct the inquirer in successful research.

In process of time many important discoveries have been made, which have been gradually assented to, as prejudice could give place: for allowing that it takes a century to make a discovery, it requires another century to remove a prejudice. Such is the force of attachment, and the power of habit, that when once the mind is established in wrong, it will hardly be restored to right; the mightiest efforts of reason are too feeble, to shake the foundations of error, in those minds, wherein ignorance and indolence have conspired against truth; such a conspiracy is too common and too formidable to permit a hope of speedy reformation from popular wrong. The uncultivated mind is more prone to judge than to investi-

gate; to censure than to commend: and indeed, in general there is not a more certain criterion of ignorance, than hasty and inconsiderate judgment.

It is the business, and the object of true philosophy, to discover truth, to explore, to weigh, to compare and to calculate, proportion, quantity, cause, and effect; and to ascertain the circumstances, conditions, relations, and qualities of objects for the ultimate purpose of mental instruction, and social order; much indeed has been done in a few districts of the globe, where tyranny, and ignorance have not usurped the dominion, and avarice and superstition, have not smitten, and paralized the nations with the witcheries of their wand, and already enthraled their wretched victims in the chains of despotism. O! wretched condition of humanity; where the human mind is cut off from the avenues of intelligence, where the voice of truth is not heard in the land, religion and benevolence have fled affrighed, and reason and justice deserted the benighted realm.

But what shall we say to numerous instances of ignorance, superstition, and bigotry, in our own enlightened district, where the voice of instruction is heard in every quarter, where there is no excuse for ignorance, and no cause, but indolence. And is it not equally strange, that many people, who do indeed evince a degree of solicitude to attain to knowledge will nevertheless content themselves with mere chaff, and will not be at the pains to discriminate between, mere opinions, and facts, but will cherish a sentiment, and reject a truth. Nay, the former they will advocate, and fight for with vehemence, which is not worth a vapour air, while they remain totally ignorant of substantial and interesting truth.

The work before us is a general survey of natural philosophy, and is properly adapted for that class of readers, who do not wish to be perplexed with mathematical philosophy; and especially for those who love to contemplate the goodness, wisdom, and power of the Creator, displayed in his works.

By acquainting ourselves with subjects in natural philosophy, we enter into a kind of association with nature's works, and unite in the general concert of her extensive choir. By thus acquainting, and familiarizing ourselves with the works of nature, we become as it were a member of her family, and participate in her felicities: but while we remain ignorant, we are like strangers and sojourners in a foreign land, unknowing and unknown.

Among the first articles which arrest our attention on a contemplation of nature's works, are, the infinite variety which we see every where around us, and the mutability of all things.

To our limited means of knowledge the varieties of being are infinite; had they been so few in number, that we could have comprehended them without an effort, we should have been apt to associate the contempt of familiarity with our ideas of them, the scenery around us would have become familiar and insipid. It would have afforded the mind no pleasing anticipations of novelty, for such is the construction of the human mind that it delights in novelty, variety, and change. But such is the ample provision of nature, that man, with all his united labours, ingenuity, and research, and with all his rage for novelty, during a space of near six thousand years has been able to explore only a small portion of the variety of being.

But not only the variety of specific being, but the perpetual change and progression of being, contributes to diversify the scenery of nature. Of all the vast variety of being that every where surround us, we behold nothing permanent, nothing durable, nothing exempt from change; the laws of mutation are as radical, and as firmly established, as the laws of being: the continued existence of all creatures, in this transitory state, depends on successive supplies of nutrition,

which failing them, they suffer disorganization and death, this we do not only witness in the scene around us, but we experience it also in ourselves, this frail and changeable body,

——————wond'rously combined,
An habitation for the mind;
Supported by an equal stay,
Consisting of well temper'd clay.
Solids, and fluids this combin'd,
In mutual operation joined;
In due consistence form the soul*
And the just medium makes it whole.
But should it swerve the equal reign,
It feels the error, in the pain;
Does for its native balance pant,
And every sense of pain is want.
Each sense of pain is nature's cries,
But calling for its just supplies;
Those just supplies, the life's main stay,
Th' appropriations of the day;
And what the appetites do claim,
Is what still feeds the vital flame.
And this you know, no longer fed,
No more the living, but the dead,
Thus, through the mere suspended strife,
The daily bread preserves the life.
And as through varying life you range,
To-day's support, to-morrow's change,
Thus as the days successive roll,
The body new, and new the soul,
You date the period of your birth,
Some ten, or sixty years on earth:
But mark the periods as they flow,
You'll find it scarce nine days ago.
You start; but 'twas the truth I told,
And I repeat, scarce nine days old.
The same are no two periods found,
Through nature's ever varying round,
But all is through th' eternal range,
Subjected to momentous change.
And change is through th' extensive plan,
Not more conspicuous than in man,
Through various spheres he wings his way,
A new creation of each day.
And change for better or for worse,
He shares the blessing or the curse.
By springs suspended all sublime,
He hugs the floating car of time,
And springs to change, to life, and strange,
To live he must keep pace with change

* The principle of life.

Life, tott'ring at its post adheres,
Assimilating with the spheres.
But when by heavy burdens press'd,
It sinks repining and distress'd:
Unequal to the mortal strife,
Lo! dies, the vital source of life.

Another invariable law of nature, is that of attraction, and which appears to pervade the entire universe. It is that relative capacity of matter by which particles enter into a state of union, or are retained in that of solution. By the operation of this law the three various states of matter are produced: the solid, the fluid, and the aeriform states. And there is every reason to conclude from the uniform results of innumerable experiments, that every species of matter is capable of entering alternately into these several states; and there is probably no situation or condition in which matter can be placed, where it can remain independent of the operation of this law.

Various phenomena result to the operation of this law. By it bodies are reduced to all the various grades of density, from the most ponderous, to the most rarefied states: by its influence, every particle of matter is put in motion, and all the operations of nature effected; and by its agency, also, it would appear, that worlds are suspended at distances from each other, proportional to their relative capacities. On these fundamental principles, is founded the whole of the modern philosophy, as it relates to astronomy, chemistry, &c. and all those branches wherein the relations of matter are considered: and every calculation and experiment hitherto, has confirmed the theory.

But the operations of this law are not always uniform, sometimes they are easy and gradual, as in the easy growth and accretion of bodies, in gentle breezes and moderate showers. sometimes they are violent, and instantaneous, and proclaim their sovereignty and power in thunder, shaking the spheres with storms, and the earth with convulsions.

By acquainting ourselves with the various subjects in natural philosophy, we disarm nature, as it were, of her terrors, and she assumes a smiling aspect, where superstition bedecked her in frowns: we can behold her inviting where before she appeared forbidding; her horrors are converted into charms, to the mind that can contemplate her in her appropriate characters. We can comprehend in some degree,

——————what dire defect,
Hath wrought the terrible effect;
Distorted nature to the pole,
Bids loud tremendous thunders roll,
Convenes the terrors of the sky,
And makes the ragged light'nings fly:
That darts tempestuous glooms around,
And pours an ocean to the ground,
That bids the hurricane descend,
And trees, and rocks, and mountains rend,
That makes the tott'ring structure reel,
And parts her solid nerves of steel,
While terrors all around conspire,
And flames, to set the stubble worlds on fire.

INTRODUCTION.

OF THE GRADUAL IMPROVEMENT OF NATURAL PHILOSOPHY.

1. NATURAL PHILOSOPHY treats both of God himself, and of his creatures, visible and invisible. Of these I purpose to speak in such a manner, as to ascend from the consideration of man, through all the orders of things, as they are farther and farther removed from us, to God the centre of all knowledge. (I mean, of *visible* things;—of the *invisible* world we cannot know much, while we dwell in houses of clay.) Thus speculative philosophy ascends from man to God; practical, descends from God to man.

2. The most ancient nations, the Egyptians and Hebrews in particular, philosophized much concerning God, and concerning *Genii*, good or evil spirits, of an order superior to man. What they taught concerning the visible world, related chiefly to its origin, the changes it was to undergo, and its final dissolution. But on all these heads, they only delivered to their posterity, what they had received from their forefathers.

3. Among the Greeks, Thales Milesius and his followers, applied themselves, with grest industry, to discover, with the best helps they had, the material causes, of natural things. They were succeeded by others, who more curiously searched into the structure of natural bodies. Here the foundation of natural history was laid, in various observations on plants, animals, and other things. And herein the endeavours of Aristotle, and Theophrastus in particular, are to be commended. Yet in other respects, Aristotle did not promote, but rather obstruct the knowledge of nature: for he made philosophy as unintelligible, by his abstract and metaphysical notions, as Plato, Pythagoras and others did, by their ideas, numbers, and symbols.

4. In succeeding times, when the four Greek sects, the *Platonic*, *Peripatetic*, *Epicurean*, and *Stoic* divided the western world between them, the Platonists almost confined themselves and their opinions to the subject of divinity; the Peripatetics regarded little but logic; the Stoics little but moral philosophy; and the Epicureans had small concern about any, being immersed in sensual pleasures: so that none of them made any considerable improvement in any branch of natural philosophy.

5. When the utter barbarism which followed, was a little dispelled Aristotle began to reign. His followers, (the shool-men, as they were called) might have improved natural philosophy, if (like their master) they had diligently cultivated the knowledge of nature, and searched out the properties of particular things. But it was their misfortune, to neglect what was commendable in him, and to follow only what was blame-worthy; so as to obscure and pollute all philosophy, with abstract, idle and vain speculations. Yet some of them, after the Arabians had introduced the knowledge of chemistry into Europe, were wise above the age they lived in; and penetrated so far into the secret recesses of nature, as scarcely to escape the suspicion of magic. Such were Roger Bacon and Albertus Magnus.

6. After the revival of learning, as all other branches of philosophy, so this in particular received new light. And none was more serviceable herein than lord Bacon: who, well understanding the defects of the school-philosophy, incited all lovers of natural philosophy to a diligent search into natural history. And he himself led the way, by many experiments and observations.

7. After this, not single persons only, but whole societies applied themselves carefully to make experiments; that having accurately observed the structure and properties of each body, they might the more safely judge of its nature. And the advantages, which have arisen from hence, manifestly appear from the memoirs of the Royal Society at London; of the Academy of Sciences at Paris; and those of the same kind in Germany, as well as several other parts of Europe.

8. To mention but a few of the late discoveries in each branch of natural philosophy. With regard to the structure of a human body, how many things have modern anatomists discovered, which were either little understood by the ancients, or wholly unknown to them? Such, for instance, is the circulation of the blood, discovered by Dr. William Harvey, whose "Anatomic Exercitations," concerning it were first published in the year 1628. Such were the lacteal veins, discovered first in brutes, by Casper Asellius, of Cremona; and soon after in men. Such the thoracic duct, and receptacle of the chyle, observed first by Dr. John Pecquet; of Paris, whereby the whole course of the blood is now clearly understood.

9. Dr. Harvey improved natural philosophy, by another no less eminent discovery! for he was the first of the moderns that shewed all animals to be generated from eggs. That the ancients knew and taught this, (Orpheus in particular) cannot reasonably be doubted. But as the knowledge of it was entirely lost, to revive was the same thing as to invent it. It is obvious, how great a light this pours upon that dark subject, with regard to the generation of men, as well as of other animals.

10. Another remarkable discovery in the last century, was that of the transfusion of the blood. The blood of a young, lively, healthy animal was transfused, by means of a small, silver tube, properly adjusted into the veins of another, which was old, weak, and sickly. And the effect amazed all the beholders. When the experiment was tried before several of the Royal Society, a feeble, worn-out dog, ready to die with age, and hardly able to trail his legs after him, was no sooner filled with young blood, than he leaped up as from sleep, shook himself, and ran up and down. as lively and active as a puppy. In France the experiment has been made upon men, and with as surprising success. What pity, that so important an experiment should ever fall into disuse! That it is not still repeated upon proper occasions! Especially where all other means fail.

11. It cannot be denied, that physicians have signally improved this branch of philosophy, as they have continual opportunities of making new discoveries in the human body. In diseases themselves, the wonderful wisdom of the Author of nature appears: and by means of them many hidden recesses of the human frame are unexpectedly discovered. The powers of medicine also variously exerting themselves, lay open many secrets of nature.

12. And how many things in all bodies, as well as in the human, which eluded all the art and industry of the ancients, have the moderns discovered by the help of microscopes? Although these are not properly a modern invention: it being certain, something of this kind was in use many hundred years ago. There are several works of great antiquity still extant; the beauties of which cannot even be discerned, much less could they have been wrought, by the finest naked eye, which ever was in the world. Such is that seal, now in the cabinet of the king of France, allowed to be at least fifteen hundred years old, six-tenths of an inch long, and four broad, which to the naked eye presents only a confused groupe, but surveyed with a microscope, distinctly exhibits trees, a river, a boat, and sixteen or seventeen persons.

13. Now whatever assists us in searching out the structure of a human body, equally helps us to find out the nature and properties of other animals. Hence in these likewise we have received great light, from anatomical and microscopical observations. Those especially who have bestowed their whole time and thoughts on one kind of animals (as Dr. Willoughby, on fishes, Dr. Swammerdam, of Amsterdam, on insects) have illustrated to a surprising degree, the subjects on which they wrote.

14. Many have diligently searched into the nature of plants; particularly Mr. Ray, who has not only ranged them in a new method, but also wrote an elaborate history of them. Others have described,

with equal diligence, either plants in general, or those of a particular country. And others have shewn the like industry in finding out and explaining the nature of stones, metals, minerals, and other fossils.

15. Nor is it strange that the moderns have penetrated farther into the recesses of nature than the ancients, considering the advantages they have received, from the art of chemistry. Not that this is an invention of later ages: it was in some measure known long ago. But as this art has been cultivated in our age, with far greater accuracy than ever, so by this means many properties of natural bodies have been discovered; of fossils in particular.

16. But none of these have so much engaged the study of the learned, or so well deserved it, as the load-stone. Its attractive force was known to the ancients, and the origin of that discovery is recorded by Pliny. But it does not appear that they knew of its pointing to the pole, or of the use of the compass. This (the compass) was invented by John Goia, in the year 1300. But it has since been observed, that the magnetic needle seldom points exactly to the pole; but varies from it some degrees to the east or west, in a fixed and regular order.

17. Nearly related to the nature of fossils is glass, which was well known to the ancients, being mentioned by Plutarch and Lucian among the Greeks, by Lucretius, Pliny, and others among the Latins. Yet the art of making glass has been since their times abundantly improved. One branch of this is, the art of making burning-glasses, which are now brought to so great perfection, as either to melt or reduce to ashes the most solid bodies, in a few moments. If these were known to the ancients at all (which may reasonably be doubted), yet the art was wholly lost for many ages, and not recovered till of late years.

18. But the most extraordinary, and important discoveries and improvements which have been made in later ages, which have enriched the world with useful knowledge, and exalted the modern, to a conspicuous degree of pre-eminence over the ancient philosophy; which have ushered in a new dawn to the scientific world, and substituted rational theories, for obscure dogmas; are unquestionably those in the chemical department of philosophy. Air, Water, Earth and Fire, the four Elements of the ancients, are now ascertained, beyond all controversy and doubt, not to be simple elementary bodies, but highly compound, and of very heterogeneous character. The common atmospheric air, is found by abundant experiment, to consist of about three parts of nitrogen, and one of oxygen. There are also found to be a great variety of airs, which are constituted by their different bases, as hydrogenic, carbonated, sulphurated, airs, &c.

19. Water is also found to be composed of two separate airs, hydrogen, and oxygen: which, by synthetical process, have been conver-

ted into water innumerable times. Water is also found to consist of infinite variety, according to the various bases with which it unites, and the quantities of those bases. Hence we discriminate, pure water, saline water, mineral water, &c. Dr. Priestly and Mr. Lavosier, were principally concerned in the discovery of the composition of water. This great discovery was made soon after Dr. Priestly discovered the composition of air in the year 1774.

20. The earth is also ascertained, to consist of different aerial bases: and there is no known substance of it, that has not yielded to the intensity of caloric, and been converted into air. The simple components of bodies, found by analyzation, are now denominated the elements of bodies. Hence the elements are now made to consist of light, caloric; the different gasses, which in the state of union, compose air, and water; salts, earths, and metals, consisting of 49 distinct simple elementary substances: and not as was formerly reckoned by Aristotle, Empedocles, and their followers, air, earth, water, and fire, the latter of which is found to be a mere modification of caloric.

21. The discoveries, and observations of the fixed stars, by Dr. Herschel, and their aberration, by Dr. Bradley, are deemed amongst the most important of later ages. The use of telescopes, and the improved philosophical apparatus, have indeed introduced the scientific mind, to a new theatre for contemplation and conjecture; and furnished him with more ample means, for investigation and research.

22. Hence it is that the present age, has a vast advantage over antiquity, by having found out new principles, and new means, for investigating the secrets of nature. But much yet remains to be done, as much yet consists in mere conjecture; and much must necessarily continue to consist in opinion, in consequence of our finite means; and it should be the business of the philosopher to form those which are most rational, and best supported by, analogy and fact.

23. What remains of natural philosophy, is, the doctrine concerning God and spirits. But in the tracing of this we can neither depend upon reason nor experiment. Whatsoever men know or can know concerning them, must be drawn from the oracles of God. Here, therefore, we are to look for no new improvements; but to stand in the good old paths: to content ourselves with what God has been pleased to reveal; with the faith once delivered to the saints.

PART THE FIRST.

OF MAN.

CHAPTER I.

OF THE STRUCTURE OF THE HUMAN BODY.

1. As MAN ought to know himself best, we begin our treatise here. And first, let us contemplate the human body. The parts of this are either *solid* or *fluid*. Those of the solid, of which the rest are formed, are termed *similar* parts. Such as fibres, bones, membranes, ligaments, arteries, veins, lymphatic vessels, nerves, flesh, muscles, tendons: and those general coverings of the body, the cuticle, the skin, fat, and the paniculus carnosus.

2. A FIBRE* is a kind of slender thread, of which all the other parts of the body are woven: according to the difference of which, the substance of the fibres is different also.

* While considering subjects in natural philosophy, three things particularly arrest our attention with regard to solid bodies, from the construction of a fibre, to that of a world, and those are, extension, form, and capacity.

All the particles which compose the material world, have a tendency to compact together in certain circumstances, and extend to large bodies of different degrees of solidity. This is not only the case with particles of the same nature, but with particles of different natures: and this is so universally, and uniformly the case, that they are considered as laws, by which the operations of nature are directed. A union of particles of the same nature, is called the law of aggragation, or the attraction of cohesion, and that of particles of a different nature, the attraction of composition, but this aggragation, and composition of bodies, exhibit very different processes. In general the spontaneous accumulations are gradual, and then bodies are said to grow. But there is a process by which particles enter into the most compact state of union, and that is, after having been held in solution, in certain menstruum, the menstruum is evaporated, and the particles remain tested together; in which situation the laws of attraction exert their force upon them, and reduce them to the most intimate connection. This is termed chrystalization. In another instance they are set at liberty by a contact with some other substance, which has a superior attraction for the menstruum, and this process is termed precipitation.

There is yet another process by which the extension of bodies takes place, which in consequence of its heterogenous productions, can hardly be considered as ranking with the uniform laws of nature. It is called adhesion; it takes place when particles adhere together, by means of some intermediate gluey substance, or some

The finest microscopes have been hitherto insufficient to lead us to a sight of the smallest moving and nervous fibrils, and still less can we ever expect from them, to get any sensible idea of the mechanism by which sensation and motion are affected.

substance which is capable of hardening, and holding particles together in a mass, so as to form a solid body of this description are certain processes of petrifaction, and ossification, by which means rocks, fossils, minerals, &c. are formed.

These are the principle laws by which particles are united and extended to increased Magnitudes. The attraction of cohesion, the attraction of composition, chrystalization; precipitation, and adhesion. And the extension, and solidity of all bodies, may be considered as originating in one or other of these processes.—Unless we consider the law of gravitation, as ranking among the solidifying principles; which is a mere resting of particles one on another, upon the surface of the earth. But this may be considered rather as a general law, by which the other laws are put in operation.

The process and formation of a fleshy fibre, exhibit phenomena very similar to those of chrystalization. All the substances in nature can be held in solution, by various menstruum, and precipitated, or separated from their solvents, by various means. By whatever means they escape from their solution they exhibit an uniform tendency to consolidate in certain form or strata; this process of chrystalization is demonstrative, that form in a certain degree at least, is inherent in matter. Chrystals are denominated according to the particular form which they assume, and are termed needles, cubes, scales, triahedrons, quadrahedrons, hexahedrons, octahedrons, decahedrons, &c. and are further described, according to their difference of form. All the substances which compose the animate body, from the softest and finest fibre, to the hardest, and most compact, the bones, have been held in solution, in the blood and other humours; and have escaped from their solution, by a contact with particular humours or passing through certain strainers, and assumed the form which is proper to their particular capacity. And they constitute accordingly, bones, cartilages, muscles, tendons, arteries, veins, nerves, membranes, &c. and the different secreted humours.

There is one circumstances attending bodies in solution, which is very remarkable; that is, the distance at which the particles are suspended in the mentruum; they appear to recede from each other at equidistances, if more of the menstruum be added they still recede farther, and so in proportion to the space they are to occupy; until they become apparently lost in distance. In this situation the particles evidently become repellant, and they fly from each other, as if with aversion. This is evidence, if evidence can be in the case, that every particle of matter is inveloped in its own proper atmosphere, and that it is endued with the capacity to exert, and extend it, according to the particular circumstances in which it is situated. This capacity is called elasticity, and is prodigious in the aireform state of matter.

Here we have presented to our contemplation, a phenomenon which commands our highest admiration. That the same class of particles in one situation, are capable of entering into the most compact state, and cleaving to each other with the utmost eagerness. In another situation, exhibit equal eagerness to shun each other, and preserve the utmost distance. On this remarkable capacity of matter, depends abundance of the phenomena of nature. These opposite states of matter, may be fitly discriminated by the terms, active and passive. Or the positive and negative state of matter: similar to that of electricity.

But it must not be understood, that those expressions are intended to convey the idea, that form and matter are universally identical; at least the present at-

But the least fibres which appear to the sight, are of two kinds. Of these two kinds of fibres, as we shall presently see, we may distinguish the former by the title of filamentary, and the latter of membranous.

tainments in science, are not sufficient to ascertain the fact. We can contemplate nature as a great Chemist, and be satisfied, that she maintains a perpetual uniformity in her operations; we can infer by parity of reason, that she is systematic in all her proceedings; and that chance, and fortune, have very little to do with her arrangements. But we cannot trace her through the labyrinth of her measures, nor scan the infinite variety of her stores. We are charmed with the simplicity of her operations, such as we can contemplate comprehensively, but we soon lose ourselves, by pursuing her in her compound recesses. The process of the chrystalization of salts, may be regarded as a simple process in nature, and hence we infer the inherent property of form in matter. But when we come to consider the class of organized being, and observe how system rolls in system, and species, live on species; and how one variety is made subservient to another, how the very same matter in one stage of existence, constitutes an integrant part of earth; then of vegetables; then of animals; then an essential and powerful ingredient in the chemical elaborations of nature: it is then, that the utmost refinements of reason, sink into feeble conjecture.

It is however established on unexceptionable authority, that of experiment, that the same matter is capable of assuming different forms, by entering into different compounds; that it is capable of supplying alternately the different states of being. The matter which forms an animal fibre, may in another situation form a vegetable fibre, but these considerations evidently point out certain bases of form, or an active and passive principle in compounds; a governing and subordinate agency, or certain laws by which the various modifications of matter are directed. The immediate acting, and governing principle, which directed the construction and formation of a vegetable fibre, is not precisely the same as that, which directed the construction and formation of an animal fibre. And that principle, which can condense, concrete, and render matter subservient to form an action, is evidently wanting wherein the same matter is dilated, and dissipated in the regions of the air.

While pursuing a train of reflections, circumscribed by the limits of known cause and effect, confining our considerations to mere substance, and form, and contemplating the consolidation of matter, in merely unorganized bodies, by the known laws of aggragation, composition, and chrystalization, man himself might be considered as a living chrystal. But when our contemplation becomes fixed on the capacity of organized being, and we annex to the account, sensibility, instinct, thought, reflection, reason, conscience, vision, and conception, our ideas are launched into a world of mystery, and we sink in unfathomable depths. Philosophy itself in its most formidable and gigantic attitude, with its whole train of arguments, experiments, traductions, inferences and analogies, sinks into a mere pigmy: and man with all his knowledge, and sagacity, still finds, there is something beyond him, out of his reach, and beyond his conception, a wisdom, and omnipotence which ordains, and sustains all things, and that is God.

But notwithstanding it is a sufficient reason at all times, and in all cases, that God made all things, by his wisdom, and power, yet is it a duty nevertheless incumbent on man, to search after knowledge; in prudence, and meekness, without ostentation, without presumption, and without discontent: and knowledge so acquired shall prove a lasting benefit, and a source of felicity.

The first kind of these fibres is lineal, namely, such a form as makes their length considerably large in proportion to their breadth ; and which, by disposing of the particles in a right line, must of course lay them generally parallel with the neighbouring or contiguous fibres. Examples of such fibres we see in the bones, and most easily in those of a fœtus ; and likewise in the tendons, ligaments and muscles ; only we must here always remember, that the eye never reaches to the smallest fibres, but to larger ones made up of the smallest, and like to them in slenderness, placed together in a rectilineal course. That these are not different from the smallest fibres, we are persuaded by the most accurate microscopes of Muyses and Lewenloeck ; by which the muscular fibres, divided even to the last, appear similar to the larger, till, at length, they seem mere lines like spiders threads.

The second kind of fibres are those which are conjoined with a breadth frequently larger than their length.

From what has been said, we may admire nature no less for her wise economy than simplicity, in thus forming all that variety of parts we see in an animal, from a few primary simple substances, whence the body is not only augmented from a single point in the ovum to its full growth and stature ; but like the timbers of a ship, is also every day repaired during life, till at length, not two jots of the old or first materials remain. This renovation of parts is made slower in some constitutions, and in some organs, than in others. How quickly the animal humours, with the hair, nails, &c. are renewed, every one knows : and we may venture to say, that once in three years the change is universal ; at the end of which time, though a man remains the same identical person, he is not the same matter.

3. But we proceed from these simple fibres, to the next least compounded solid which they compose ; viz. cellular web-like substance.

This is made up partly of the simple fibres, and partly by an infinite number of little plates or scales, which joined in various directions, intercept small cells and web-like spaces ; and by extending round every, even the least moving solid parts of the body, conjoins them altogether in such a manner as not only sustains, but allows them a free and ample motion.

The extension of this substance, not only with the skin round the whole body, but also round every viscus or organ, and round every

Finally it appears, that there is a power which governs all things, and which formed all things with judgment, and discretion. A wisdom which designs, and an omnipotence which executes : a power to which a fibre is as a world, and a world as a fibre ; a power which is self-existent, and eternal, which is unabated by change, and which cannot be augmented by duration. And the little changes and variations which we see, are but diversities of that power ; from which nothing can be subtracted, and to which nothing can be added, neither in number, nor in magnitude.

individual, moving fibre or vessel of them, into the cavities of the bones, and even the substance of the brain and its medulla, is a wonderful discovery. This substance, in its ultimate state being composed of simple membranes, when compacted and convoluted gives birth to the least or most simple vessels, which again reflected through plates of the same substance compacted together, make compound and vascular membranes; to the consideration of which we next proceed.

Out of this cellular substance compacted by a concretion of the membranous plates or partitions, and pressed together by the force of the incumbent muscles, and distending fluids, arise other broad and flat plates or skins in various parts of the body; which being generally disposed in one and the same direction, seems to have a better right to the name of membrane than the former; and these being convoluted into cones and cylinders, pervaded by a flux of some juice or liquors brought to them; put on the name of vessels, or else being extended round some space that is in a plane, parallel to itself, we call it a *tunic* or coat.

This cellular substance in the human body, is found throughout the whole; wherever any vessel or moving muscular fibre can be traced, and this without the least exception, that I know of, in any part whatever. But so far as we can trace, it hardly ever admits of any fat in the cells; which are rather moistened by a watery vapour, somewhat oily, exhaled out of the arteries and received again into the veins.

Its plates or scales are still more loose and open where it divides the muscles and all their fibres (even to the ultimate fibre;) and likewise where it surrounds and sustains the least vessels with their free motion. That within the cavities of the bones is also made up of boney plates, with membranous ones intermixed; and lastly, it is the most loose and open of all, round the surface of the body on all sides, betwixt the muscles and the skin.

Through this cellular substance the small vessels are spread, and ramified in all parts of the body; from whose arterial extremities the fat is deposited into the cells, and afterwards absorbed by the venal orifices. This passage from the arteries into the adipose cells, is so free and short, that there must needs be very large mouths by which they open, and by which they give admittance to injected mercury, air, or water. The oily fat, in this substance, is separated and expelled from the artery; not by any long ducts, but by transuding on all sides through the whole extent of the vessel. How quickly it is collected from the arteries, appears from the speedy renovation of it, by a returning fatness after acute diseases.

With regard to the sponge-like communications of this substance, it is remarkable, the intervals or spaces betwixt the plates or scales

that make up their sides in the cellular membrane, are every where open, and form one continuous cavity throughout the whole body.

That out of this substance, joined with vessels, nerves, muscular and tendinous fibres (a great part of all which are before formed of this substance only,) all the viscera, all the muscles and glands, with their ligaments and capsules, are entirely composed; and that only from the different length, tension, quantity or proportion of this, the diversity of our glands, and viscera arises; and lastly, that this alone makes up by far the greatest part of the whole body, we are certain, if the whole be not formed out of the cellular filaments, of this kind.

4. The hardest part of the body, white and void of sense, is termed a BONE. The bones are covered with a thin skin, called the periosteum, extremely sensible.

The bones consist of thin plates, lying one upon another; and these again, of fibres running lengthways; some to the extremity of the bone, some not so far. Yet none of them terminate there; but are continued transversely, and as it were arched, the fibres of one side meeting and uniting with those of the other, and this at each extremity.

These plates are differently disposed in different bones: in those that have a large cavity, they are contiguous on each side, and very closely united. In those whose cavities are small, many of the inner plates are distant from each other; having little long cells between them. In bones whose plates are contiguous, there are pores through and between them (beside those for the blood-vessels.) The first pierce them transversely, from the cavity to the external surface of each plate. The second run lengthways between the plates, and diffuse an oil with which they are supplied by the transverse pores.

The bones are generally bigger at each end than in the middle, that the joints may be firm, and the bones not so easily dislocated. But to strengthen the middle of the bone, the fibres there are more closely compacted. Likewise, the bone, being large and hollow, is not so easily broke, as if it had been solid and smaller: for of two bones of equal length and equal number of fibres, that is stronger which has the larger diameter.

The blood-vessels usually enter the ends of the bones; the arteries at one end, the veins at the other. The medullary vessels commonly enter the sides of the bone, and that obliquely.

The marrow is covered with a membrane, wherein are inclosed little bags. In these bags are glandulous bladders, serving both to screen the marrow from the blood, and to receive it. Both these and the bags have passages into each other, whereby the marrow has free course. It passes first through the transverse pores of the first

internal plate into the longitudinal ones. Thence it proceeds into other transverse pores, when it alters its course again, and exudes farther. Thus it passes alternately through and between the plates, till it is diffused throughout. In this manner it is diffused through bones, whose plates are contiguous. But where the plates are at a distance, the small cells contain glands, which directly supply the plates with marrow.

The marrow not only serves to keep the substance of the bone moist, but to lubricate the joints, and to hinder the ends of the bone, from being worn or over-heated with motion. It also moistens the ligaments, which tie them to each other: as do likewise the glands found in all the joints. The back-bone hath these two things peculiarly remarkable: 1. Its different articulations from the other joints of the body. For here most of the joints are flat, and withal guarded with asperities and hollows, made for catching and holding; so as firmly to lock and keep the joints from luxations, but withal to afford them such a motion, as is necessary for the incurvations of the body. 2. The difference of its own joints in the neck, back and loins. In the neck the two upper *vertebræ* are curiously made, and jointed (different from the rest) for the commodious and easy bending and turning the head every way. In the *thorax*, and back, the joints are more close and firm; and in the loins more lax and pliant; also the knobs and sockets are turned a quite contrary way, to answer the occasions the body hath to bend more there, than higher in the back. So that its structure is the very best that can be contrived; for had it been all bone, we could have had no motion in our body; had it been two or three bones articulated for motion, the *medulla spinalis* must have been necessarily bruised at every angle or joint; besides, the whole would not have been so pliable, for the several postures we have occasion to put ourselves in. If it had been made of several bones without intervening cartilages, we should have had no more use of it than if it had been but one bone. If each *vertebra* had had its own distinct cartilage, it might have been easily dislocated. And lastly, the oblique processes of each superior and inferior *vertebra*, keep the middle one, that it can neither be thrust backwards nor forwards to compress the *medulla spinalis*.

The pelvis made in the belly by the ilium, *ossa coxendicis* and *pubis*, is larger in a female than in a male skeleton, that there be more room for the laying of the *viscera* and *fœtus*. So the cartilage bracing the two sharebones, is twice thicker and laxer in women than in men. As also is the cartilage that ties the *os sacrum* to its vertebra; and all, to give way to the passage of the fœtus.

Another considerable difference is, in the cartilaginous production of the seven long ribs, whereby they are braced to the breast-bone.

These are harder and firmer in women than in men; the better to support the weight of the breasts, the sucking infants, &c.

It is remarkable in the joints, and a manifest act of caution and design, 1. That although the motion of the limbs be circular, yet the centre of that motion is not in a point, but an ample superfices. In a point, the bones would wear and penetrate one another, and the joints would be exceeding weak. But the joint consisting of two large superfices, concave and convex, some furrowed and ridged, some like a ball and socket, and all lubricated with an oily substance; they are incomparably prepared both for motion and strength. 2. That the bones next the joints are not spungy, as their extremities commonly are, nor hard and brittle; but capped with a strong, tough, smooth, cartilaginous substance, serving both for strength and motion.

For affording this oily matter there are *glandules* very commodiously placed near the joints, so as not to suffer too great compression by the motion of the neighbouring bones, and yet to receive a due pressure, to cause a sufficient emission of the oil into the joints. Another thing considerable is, that the excretory ducts of the mucilaginous glands have some length in their passage from the glands to their mouths; which is a good contrivance, to prevent their mouth being oppressed by the mucilage, and also to hinder the too plentiful effusion thereof but yet to afford a due expressure of it at all times, and on all occasions; particularly in violent and long-continued motions of the joints, when there is a greater than ordinary expense of it.

That the nourishment taken in, is continually conveyed through the bones, as well as the flesh, appears from an easy experiment. Mix red liquor with the food of any animal, and in a short time the bones are died red. When madder root was mixed with the food of a cock, which died after sixteen days, all his bones were red, the internal parts as well as the external. And the most solid parts were the most deeply tinctured; in swine, the teeth above all the rest.

5. Annexed to the bones are the CARTILAGES, white, flexible and smooth; most of which in process of time become bones, hard and quite void of sense.

A cartilage is an elastic substance, uniformly compact and somewhat transparent, harder and more brittle than a ligament, softer than a bone. It is covered with a fine membrane, folded over the bone, from where the ligament is inserted. Every joint is inserted with a membrane, which forms a complete bag, and covers every thing within the articulation. The blood-vessels are so small that they do not admit the red globules, and are demonstrable only in very young subjects. All round the neck of the bone, there are numerous arteries and veins which spread into smaller branches, and communicate with each other. These divide into still smaller branches on the ad-

joining surface, as they run toward the centre of the cartilage. We can seldom trace them into its substance, because they end abruptly, at the edge of the cartilage. The larger vessels plunge in by numberless small holes, and disperse themselves into branches between the cartilage and bone. From these again there arise many short, but small twigs, which shoot toward the outward surface. This distribution of the blood-vessels is very peculiar, and calculated for obviating great inconveniences. Had they run on the outward surface, the pressure and motion of the two cartilages must have occasioned frequent obstructions and inflammations. But by creeping round the cartilaginous brim, where there is little friction, or under the cartilage, where there is none, they are perfectly well defended from all such accidents.

Cartilages are admirably contrived for all the purposes of motion. By their uniform surface they move one upon another with ease: by their soft, smooth and slippery surface, mutual abrasion is prevented. By their flexibility, the contiguous surfaces are constantly adapted to each other. By their elasticity the violence of any shock, which might happen in running, jumping, or the like, is broken; which must have been extremely pernicious, if the hard surfaces of bones had been immediately contiguous. The cartilaginous fibres appear calculated chiefly for this last advantage. To conclude, the insensibility of these cartilages, is no less wisely designed, that by this means the necessary motions of the body may be performed without pain.

6. The various parts of the body are clothed with MEMBRANES, which are whitish tunicles, extremely thin and flexible, composed of fibres interwoven with each other, as a piece of cloth is of threads. They are fastened together by a kind of cartilages, which are termed ligaments.

7. An ARTERY is a hollow canal, composed of fibres closely twisted together, which conveys the blood from the cavity of the heart to all the parts of the body.* All the arteries spring from two, the *aorta* or

* The arteries and veins, are destined for other purposes, besides the circulation of the blood. They are organs, for its complete elaboration: and the blood in its entire revolution, undergoes numerous changes; and assumes very different characters, in the different stages of circulation. In one stage it is destined to perform the work of secretion, and to carry nourishment and repletion to all parts of the body. In another, it exercises very different functions, and is employed in the work of absorption; collecting in its course, various humours, as hydrogen, carbone, and other inflammable matters, which have been collected in the different depositories. These empty into the volume of the blood, and commixing with it, change both its quality and colour; and prepare it for the process of respiration. They are then borne away in its current, to the great laboratory, the lungs; where respiration taking place, the blood assumes a new character, and becomes replenished with the necessary ingredients, to qualify it for the discharge of its ordinary functions, in its course through the arteries. The arteries

great artery, and the pulmonary artery. The latter conveys the blood from the right ventricle of the heart, through the lungs, into the left ventricle. The former conveys it from the left to all other parts of the body.

The arteries ordinarily consist of three COATS or membranes. The outermost has been generally thought to be composed of fine blood-vessels. The second is muscular, and made of firm and strong circular, or rather spiral fibres: of which there are more or fewer strata, as the artery is larger or smaller. These fibres are extremely elastic. The inmost coat is a fine dense transparent membrane, containing the blood, which otherwise would easily ooze through the spiral fibre.

On a more accurate examination it has been found, that the outermost coat of all arteries is a cellular substance, composed of fine, pellucid membranes, which may be stretched, even suddenly to a great extent without breaking. And they as suddenly collapse, when that stretching force is removed. These cells contain an oily liquor which their coats secern from the branches of the artery that are spread over them. This cellular substance of the arteries serves to connect them with the surrounding part, without hindering their actions or motions. It gives a safe passage to the vessels of their other coats, and supplies oil for lubricating them. There is also another cellular substance, between the membranes and the muscular coat.

All the arteries begin with a larger trunk, and grow less and less till they are no longer seen by the naked eye. Hence they are continued till they inosculate with the veins, and so form one uninterrupted channel.

They appear white, because their coats are of so dense a con-

and veins are especially constructed for this purpose, being successively furnished with the requisite organs, to work these several changes in the blood. This becomes an important consideration in phlebotomy, since the blood assumes such different characters in its course, it makes a very essential difference, which description is taken from a patient. And probably no science in the medical department is more capable of improvement, than that of phlebotomy. A most surprising effect was witnessed some time ago on a patient, who was reduced to a very low state, by a raging disorder. Bleeding was prescribed, as a dernier resort. A vein was opened, and but little blood flowed. The operation so far from relieving, evidently enraged the disorder. At length leeches were recommended, to be applied to the breast. And no sooner had the animals fastened, than the blood burst forth as if from imprisonment; and even after the creatures were removed, it seemed to stop with difficulty. The patient was immediately relieved, and the disorder broke. Even in the opening of a vein, it must make a very important difference, at what stage of the blood's process, a puncture is made. For it would seem from numerous instances, that in one situation, and at one time, a description of blood might be taken away which is a check to a disorder. And the loss in this case would but increase the malady. But in another particular situation, and time, the very basis of the disorder, might be drawn off with the blood, and the disorder itself broke as by a charm.

texture, that the blood is not visible through them. This proceeding from wider to narrower canals, is continually obstructed in its passage. But being pushed on from behind, it distends the coats, and causes that leaping motion called the PULSE. By this, as well as by their whiteness, arteries are distinguished from veins.

The pulse of a healthy person, rising in the morning, beats 65 in a minute; but after the fatigue of the day, it will in the evening beat 80 in that time; and again, by the night's rest or sleep, it will become less frequent, till in the morning you will find it return to 65. For the voluntary motions of the muscles, and actions of the external and internal senses, urge the venal blood on to the heart, which, being thereby oftener stimulated, makes more frequent contractions. This is the cause of those paroxysms or fits of increase, observable in all fevers towards the evening. For sleep not only retards the motion of the blood, but of all the other humours, and actions in the body.

It is one of the curious observations of Dr. Hales, that the pulse is quicker in small animals. He found the pulse of a horse slower by half than in a man, viz. 32 only in a minute; whereas in a dog, the pulse beats 97 in that time. And this we see is conformable to the blood's heat, measured by the mercurial thermometer of Farenheit's scale. For the blood in oxen, horses, and other large animals at rest, being five or six degrees cooler than in us, will not rise to our heat, but by labour; whereas, dogs, cats, and fowls, are five or six degrees hotter than we (viz. about 102;) and the latter, when sitting or brooding on their eggs for young, are still four or five degrees hotter, viz. 107 or 108, which is commonly the heat of our blood in the fit of an ague; where it is observable, that during the greatest sense of cold chill, the blood is three or four degrees hotter than in health, after which it gains four or five degrees more in the height of the hot fit, viz. 104 or 105 degrees; but in ardent fevers, where the pulse beats 140, the heat of blood will still be four or five degrees higher, viz. 110; i. e. two or three degrees more than equal to a brooding hen.

The pulse is more quick in children, and becomes slower in persons as they grow older. The salient point of an OVUM beats 134 in a minute. New born infants have their pulse 120, and from thence down to old age it grows slower, to 60 in a minute. A feverish pulse begins at 96 per minute; it is excessive at 130 or 140, which is the number of the pulse with which a person dies. The pulse beats slower in winter, and quicker in summer, by about ten strokes per minute; and under the torrid zone, it grows quicker, to 120.

8. A VEIN is a hollow canal, which receives the blood from the artery, and conveys it back to the heart. The chief veins are three, the *vena cava*, which pours the blood through a wide passage into the right ventricle of the heart; the pulmonary vein, which in like

manner pours it into the left ventricle; and the *vena portæ* which does not, like the two former, end in a large trunk; but spreads itself at each extremity into numerous branches.

In the cavity of the veins there are certain thin tunicles, which are termed VALVES. These, during the regular motion of the blood, lie close to the side of the inner coat; but in case of any obstruction, recede from it and close the passage, to prevent the blood's falling back.

9. The LYMPHATIC VESSELS are small canals full of valves, consisting of a thin transparent tunic which convey an extremely clear liquid into the mass of blood. Probably these (as well as the veins) and all the other vessels, are only continuations of the arteries.

It has been lately discovered, that the lymphatic vessels have two coats; betwixt which there are innumerable fine filaments, containing a nutricious juice, which is conveyed into all parts of the body, by a motion from the centre to the circumference, and returns through the inner pipes, of the same watery vessels. But this juice when returning, is no more water or dew, but ferment; and the vessels may be termed ferment-vessels. This ferment is conveyed into the blood, by a motion from the circumference to the centre.

The lymphatics carry their dewy particles through the glandules, which lie between the two coats. In the lowermost end of these glandules, the ferment vessels take their rise. Most of the juice of the lymphatic-vessels is discharged between the coats of the veins, arteries, and vessels, in the mesentery; to be conveyed into all parts of the body, both internal and external. Even in bearing females, the fruit is not nourished by blood, but by this nutricious juice: the remaining part of which, is transmitted into the blood through the thoracic duct and jugular veins.

10. A NERVE is a whitish, round, slender body, arising from the brain, which is supposed to convey the animal spirits to all parts of the body. What these spirits are, none can shew:* nay, we are not sure they have any being. For it is difficult to tell, whether the nerves are hollow canals, or only solid threads, enclosed in proper integuments.

* It is highly probable that philosophy, aided by the utmost skill, and industry, has been able to arrest, only a few of the more ponderous substances in nature. And we hear frequent complaints, of the great difficulty of collecting, and retaining some of those. Some there are, which are pronounced by all, unconfinable; as light, caloric, electricity, and magnetism. And there is no manner of doubt, but that there are other substances, which are more formidable agents in the operations of nature, than any we are acquainted with, which have never occurred, even to our apprehension. But very lately Galvanism has been discovered. This would appear to be the true nervous fluid, to which the nerves serve as conductors. This exhibits in a surprising manner, the office, and power of the nerves, and proclaims them the organs of sensibility, and motion.

11. The fibrous, soft, reddish part of the body is termed FLESH. All fleshy fibres are hollow, and divided through their whole length into little caverns, wherein the blood is detained, as occasion requires.

12. A GLAND is a soft and spungy body, which separates some particular liquid from the blood. The larger glands contain arteries, veins, and lymphatic vessels: but the glands of the intestines are only the tops of the arteries.

There is a kind of DOWN in the cavity of every gland which probably does the office of a filter, and is that whereby a particular humour is separated from the blood.

The structure of the down-vessel is different according to the different purposes of nature. Sometimes the liquor filtrated through it, falls drop by drop on a membrane, to which one end of the vessel is fastened, as where it is designed only to moisten the part. Sometimes many of these down-vessels spread over the inner surface of a membranous cell, into which they all pour their liquor, which is discharged at a small orifice.

These vessels are often of a great length, though they take up little room, being wound over one another, sometimes in a single knot, and sometimes in several, enclosed in a common membrane.

And hence is the distinction of glands into *conglobate* and *conglomerate.*

A conglobate gland is a little, smooth body, wrapt up in a fine, double skin; with only an artery and nerve passing in, and a vein and excretory duct going out.

A conglomerate gland is an irregular assemblage of several simple glands, which are tied together and wrapt up under one common membrane.

18. A MUSCLE is a bundle of fibres joined and fastened together, with their proper veins, arteries and nerves. It is divided into little cells by transverse fibres, parallel to each one, whereby it may be contracted and shortened, or relaxed and lengthened again. Its extreme parts are more closely compacted, which we term *tendons.* By these the muscles are connected with the neighbouring parts. A muscle generally consists of three parts: the upper, termed the *head*, the middle, termed the *belly*, and the lower part, or *tail.*

Every muscle is divisible into smaller muscles, and those into others still smaller: and so on, beyond all imagination. The last and smallest parts are muscular fibres. But there is no assignable point in any muscle, wherein there is not some nerve. And here all the nerves disappear: (in other parts their extremities expand into membranes.) It is therefore probable that the muscular fibres, are only the nerves continued.

14. The CUTICLE, or SCARF-SKIN, is an extremely thin and trans-

parent membrane, void of sense, and covering the skin all over, sticking fast to its surface, to which it is also tied by the vessels that feed it. It consists of several layers of exceeding small scales, which cover one another where it is thick. But in the lips, where it is extremely thin, they little more than touch one another.

In some creatures (as fishes), these scales are only the excretory ducts of the glands of the skin. In others, those glands have their proper ducts, opening between the scales.

It is supposed, there are in one scale 500 excretory ducts, and that a grain of sand will cover 250 scales. If so, a grain of sand will cover 125,000 of our pores.

The cuticle serves to defend the nerves of the skin, both from the air, which would dry and make them less sensible, and from rough and hard bodies, which would make a painful impression on the naked nerve.*

*Every body exposed to the atmosphere, is subject to its action, in a greater or less degree; and that action, is directed to the formation, repletion, or corrosion of those bodies. The atmosphere is a principal agent in the formation and government of the skins of animals. They are composed of various lamina, and exhibit similar phenomena to the bark of vegetables. There is a striking relation between the cutis, and tanning, which readily incorporate together, and make leather.

That the skins of animals partake much of the vegetable nature, in their construction, contexture, and relation, would be rendered apparent by numerous analogous circumstances. They not only consist of several coatings, similar to the barks of vegetables; but they are fibrous, and bulbous, and evidently organized for the process of absorption. The vegetable respiration is undoubtedly carried on through the integuments, and absorptions take place; though perhaps not exactly of the same description as those of vegetables: but under such modifications, as are requisite to adapt them to the peculiar purposes of their provision. These seem to be, to supply the recurrent blood with those ingredients, which are necessary to elaborate it in the veins; to produce the vegetable ferment, and to evolve that degree of inflammability in the blood, which is indispensable to the process of respiration in the lungs.

The contexture of the skin, is mucilaginous. The base of mucilage, is fibrina. The skin is formed of the muscus, finally exuded by the arteries; which are interwoven in the integuments, similar to that which is formed on the surface of mucilaginous liquors, when exposed to the action of the air. It is a species of chrystalization, which takes place, when the fluids which suspended the fibrous particles, are evaporated. They then cohere, and form a sheet or skin. The skin, in the regular occurrence of nature, should be of a certain proportionate consistence, to be conducive to good health. But in consequence of a variety of causes, it is subject to very considerable, and sometimes dangerous deviations.

Should the skin accumulate to too great degrees of consistence, by too powerful congelations, from whatever cause; either too fibrous a quality of the exuded mucus, or a favouring propensity of the atmosphere, it will in such case, oppose a proportionate obstruction to a regular transudation of the obsolete humours which nature in her efforts to maintain her equilibrium, casts off by the proper ducts, to be conveyed away out of the body. These not being conveyed away in due time, or in the requisite proportion, occasion too great dilations in the

Negroes have a skin between the cuticle and the true skin. They are born white; but the middle skin, in a little time, turns black, and gives that colour to the whole body.

retentive organs; whereby their elasticity and tone are destroyed. A general debility in consequence succeeds, and eventually a regurgitation of the humours must follow: and finally terminate in inflammations, which will be more or less violent, in proportion to the quantity or acrimony of the humours.

The superconsistence of the skin may take place in consequence of bad diet, filth, laziness, sickness, and many local causes. And sometimes its lamina will multiply to so prodigious an extent, as absolutely to form a reservoir of putrid humours: which will breed lice, or living animalcula, hence the origin of the disorders called the itch, louse nests, scurvy, leprosy, and numerous others, which it will not be consistent with the brevity of notes to touch upon.

Should the integuments be of too feeble a contexture, so as not to be able to oppose a due resistance to the violent attacks of the atmosphere, or to effect a regular government of the ordinary exudation. Too copious effusions may follow, and debility succeed to exhaustion. The consequences will be discoverable in the never failing concomitants of the case, as weakness, languor, a falling away of the muscles; as undue waste of the fat, and other secreted humours; the person is marked by feebleness, stupor, yawning, and inertness; and the blood appears to recede from the extremities.—This state is the foundation of numerous, violent and obstinate disorders which might have been prevented by early attention and care.

The skin is unquestionably a more important organ in the structure of the animate body, than has hitherto been conceived. It has been considered by some as a mere covering and finish to the body, to defend the nerves and muscles from too great exposure and irritation. But it is destined for other important services, the various deviations from a uniform contexture, to which it is liable, are undoubtedly an abundant source of plethora, and hydropics, on the one hand; and atrophy, and consumption on the other. While in its healthy state it administers to the nourishment, and support of the body, as well as contributes to its beauty and convenience.

The skin may be greatly assisted by art in the discharge of its respective functions. It consists of various lamina, the outermost of which is called the epedermis. This is immediately exposed to the action of the atmosphere, which continually wears it away, by its attrition and affinity: and this wearing should be equal to its growth and accumulation. But this mutuality rarely remains uninterrupted for a great length of time.

A very numerous class of diseases to which the body is liable, may be effectually remedied by cleanliness. The superabundant lamina of the skin may be worn away by frequent washing, or by a daily use of the flesh brush, or coarse hempen towels. But the most salutary, remedy, probably, is to wash in sea water, or in lukewarm water, salted to the degree of sea water. For hereby the virtue is doubled. For it not only wears away the lamina more effectually, by its attritive particles; but it penetrates them, and becomes a powerful conductor to the spontaneous electricity of the air, and the body: and restores the tone of the system in a surprising manner.

But there are other cases, of an opposite nature, wherein these washings would be so far from being beneficial, that they would be absolutely injurious, and no doubt, in some instances, fatally so. But even in these the skin may be greatly assisted, in the exercise of its organic functions, by various means: by wearing a flannel garment constantly next to it. This flannel should never be scalded with

But who can account for the following case? Sir Charles Wager had a boy about eleven years old, who was born in Virginia, of negro parents. Till he was three years old, he was like other black children. He then, without any distemper, began to have little white

hot water, or washed in lie, or with soap: it might be rinsed to advantage in soft spring water, and then dried in the open air. Sometimes the skin may be greatly assisted by wearing thicker garments, or by strengthening plasters, or fomentations, with oleaginous, odoriferous, or astringent liquids.

The skin exhibits various phenomena, which it would not be proper to pass over unnoticed, although to enter into a numerical detail, and discuss all the inferences which would follow, would swell the essay to a volume. But it will be incumbent to limit further observations to the utmost brevity. The colour of the skin has given rise to various conjectures, and some elaborate researches. Black and white are the most conspicuous to observation: notwithstanding, we observe an infinite gradation of intermediate shade. Some have ascribed the difference of colour, to difference of climate. Others to generation, and variety of species. But numerous arguments weigh against both conjectures, considered separately. They are unquestionably both concerned in the cause; and it may be remarked, that there is an infinite gradation in the cause, as there is in the shade. It is notorious that there is a vast variety of colour, or complexion, in persons of the same climate. This, therefore, is not owing to difference of climate, but to generation, or other local circumstances. It is also well known that persons moving from one climate to another, will suffer a change of complexion or colour, or they will suffer a change of complexion, from a variety of other circumstances, as different degrees of exposure, or difference states of health; and all this is not owing to generation. It may also be further remarked, that the members of the same family, will frequently exhibit very different complexions, or colours, as persons of the same climate, and that the different grades of climate, do not produce a uniform grade of colour.

There are many circumstances to countenance the idea, that colour may be so superficial, as not to affect generation: and that it may be so deep seated, as to affect it. The following case may be considered as an illustration of the fact.

A young married couple, of very fair complexion, in the latitude of forty two, had one child of a very fair complexion also; when they emigrated to one of the West India Islands, in latitude about fifteen. They had there two children, the first was moderately fair, the second exhibited a very tawney appearance. They then moved back to their native country, where they had several other children: the first was so yellow they called it the little Tawney, the second was much fairer, and the third was very fair.—Here difference of climate and generation, seemed evidently concerned. A number of arguments might be adduced to shew that the difference of human colour is not owing to any particular circumstances, but to a variety of circumstances conjointly.

There is yet another circumstance which seems to outstrip reason, and fly beyond the reach of argument. That is, what is termed a mark on the skin, which evidently takes place on the fœtus, in the womb; this exhibits another power which is formidable beyond ordinary consideration. This may be considered in every sense of the word, as procreative, it is one of that number like magnetism, which we can barely apprehend from fact, but cannot comprehend in deed. We can reason on many things, but this mocks all the efforts of human sagacity; we can only contemplate in silent wonder the phenomena of its reign,

specks upon his neck and breast. These increased with his years both in number and bigness, so that from the upper part of his neck, quite down to his knees, he was dappled with white spots, some of them broader than the palm of a man's hand. They were wonderfully white, equal to the skin of the fairest lady, only somewhat paler. His face, arms, and legs were perfectly black. He was exceedingly active, sprightly, and more ingenious than is common among that generation.

Perhaps the following fact is no less difficult to be accounted for: A negro woman, cook to colonel Barnes, in Maryland, about forty years of age, remarkably healthy, had her skin as dark as that of the most swarthy African. But that part of it next her finger nails, about fifteen years ago, became white. Her mouth soon underwent the same change, which has since gradually extended over the whole body. At present four parts in five of her skin, are white, smooth and transparent, as in a fair European, elegantly shewing the ramifications of the subjacent blood-vessels. The other parts daily lose their blackness, and partake of the prevailing colour. The neck and back retain most of the pristine hue; the head, face, breast, legs, and arms are all white. Her face and breast, when anger or shame has

it seems indeed sovereign, to which all other things are subordinate, and appears to mark the link between infinite creative power, and terrestrial beings.

What can strike with more astonishment, than the spectacle of a child being born, much in the shape and appearance of a tiger, at which animal the mother was terrified some time previous to delivery. It had hair and spots similar to the beast, and seemed to partake much of its savage ferocity. In another instance the child was much transformed to the shape and nature of a wolf, from a similar cause. It was covered with hair of the same colour, and had the howl of the young welps. Instances are very common of children being marked, with different kinds of fruit, as strawberries, cherries, plums, apples, &c. exhibiting the alternate colours of the fruit, from green to light, or deep red, or yellow. In one remarkable case the mother was surprised by the sudden and unexpected appearance of a negro, and the child that was afterwards born, had its face, neck and hands black, the rest of the body was white. Here are exhibited causes of colour remote from those of generation and climate, and places all arguments in favour of the one or the other exclusively, in the back ground; it tends to shew that the causes of the colour of the skin are various, and that it is alternately of natural specific, and accidental origin.

One thing more I would notice as highly beneficial, and that is, the combing or currying of the skin. This practice is of very great service to children, and if it was more attended to by grown people, it would be productive of very salutary effects. It is of very fine service to horses. And if the practice was introduced into the dairy, there is no question but it would produce the happiest effects. I have known the experiment tried, and the cows appeared more healthy, and the milk was evidently improved, both in quantity and quality. It is also of very great service in the fatting of cattle: it makes the animal stronger, and increases the muscular meat.

been excited in her, have been observed immediately to glow with blushes This is the naked fact: but upon what principles of philosophy can we account for it?

The SKIN covers almost all the whole body, and is formed of whitish fibres, intermixt with numberless branches of nerves, veins and arteries. On its surface are many furrows, or indented lines, having generally hairs on each side, and pores, or little holes of various sizes, serving for the transpiration of superfluous particles. Under the skin lie the subcutaneous glands, which are supposed to transmit through the pores an insensible steam, commonly believed to be of the same kind with what, when sensibly thrown out, is called sweat.

The PORES in our hands and feet are very remarkable. Survey with a glass the palm of your hand, well washed, and you may perceive innumerable little ridges, of equal bigness and distance, every where running parallel with each other: these are very observable on the ends and first joints of the fingers and thumb, and near its root, a little above the wrist.

On these ridges stand the pores, all in even rows. Through a good glass every pore looks like a fountain. The sweat may be seen to stand therein, as clear as rock water. The ridges are so placed, that they may better suit with the use and motion of the hand: those on the lower side of each triangle, to the bending in of the fingers: those on the other two sides, and on the elliptic ridges, to the pressure of the hand or fingers' ends, against any body, requiring them to yield to the right and left.

The pores are placed on these ridges, not in the furrows between them, that their structure may be less liable to be injured by compression, whereby the furrows only are dilated or contracted: the ridges constantly maintaining themselves; and so the pores are unaltered. For the same reason the pores are very large, that they may be the better preserved; though the skin be never so much compressed and condensed, by the constant labour of the hand; and so those on the feet, that they may be preserved, notwithstanding the compression of the skin, by the weight of the whole body.

Through the pores there continually transudes a subtle vapour from every point of the body, being what redounds of the aliment, comminuted to the highest degree, and sent to repair every particle of it. And the matter thus evacuated is more than is thrown out by all the other passages together.

A person of middle age found what he perspired was five-eighths of the food taken in; so that there remained only three-eighths for nourishment and all other evacuations. He observed also that so much is perspired in one day, as passes by stool in fourteen; and

more particularly, that in a night's time about sixteen ounces are usually thrown out by urine, four by stool, and about forty by insensible perspiration.

If a man eats and drinks eight pounds in a day, five pounds of it pass by perspiration: namely, about one pound within five hours after eating (perspiration being least of all soon after eating;) from the fifth to the twelfth hour, about three pounds; and from the twelfth to the sixteenth, scarcely half a pound. Exercise increases perspiration much; but it is naturally less in women than men.

While this steam flows from our body, it constantly imbibes a supply of moisture from the air, which serves to keep all its parts soft, pliant and fit for motion. Hence, from the greater moisture of the air, we perspire less in winter than in summer, and in rainy weather than in fair. Live, therefore, if possible, in a clean house, and in a pure, dry air.

This inhalation is very considerable. Dr. Keil found his body to have imbibed in one night eighteen ounces of moisture. And on a sudden change of weather from dry to wet, the inspiration sometimes exceeds the expiration: there being absorbent veins, which accompany the numberless arteries from which the perspiration is discharged. To the matter thus imbibed, not the obstruction of the pores, he ascribes what we term a COLD. Sweating cures this, by throwing out the noxious matter which was imbibed before.

The cutaneous vessels both exhaling and inhaling, are capable of contraction and relaxation, by the power of the nerves. This appears from the effects of the passions, which if joyful, increase the circulation, and relax the exhaling vessels. Those passions on the contrary, which are sorrowful, and retard the circulation, contract the exhaling vessels, as appears from the dryness and corrugation of the skin, like a goose-skin after frights; and from a diarrhœa caused by fear. But the same affections seem to open the inhaling vessels; whence the variolus or pestilential contagions are easily contracted by fear.

The benefits of insensible perspiration are so great, that life cannot be preserved without it. And the subtility, equability and plenty of what we perspire, are the grand symptoms of health.

But how little do we know even of our own frame! It has hitherto passed as an unquestionable truth, that the same matter which passes by insensible perspiration, passing in great quantities, is sweat. Whereas an ingenious physician, Dr. Rogers, has found by numerous experiments, that a person perspires abundantly less, when he sweats, than when he does not: that one who perspires twenty-four ounces in seven hours sleep, if he sweats, does not perspire above six. This he tried many times, and never found it to fail. Whence he infers, 1.

That it is not the same matter which is evacuated by insensible perspiration and by sweat: 2. That it is not evacuated through the same pores: 3. That the sweat-pores are abundantly larger and fewer, than those which serve insensible perspiration: 4. That sweat greatly hinders that perspiration, both by covering those pores with a clammy liquor, and by constringing them so that they cannot open; which must be the case, when the sweat-pores are dilated. What a field does this open!

Some queries proposed concerning perspiration, by an ingenious writer, seem to deserve a serious consideration. 1. "Why do carnivorous animals sweat so little? A fox hunted almost to death never sweats. 2. Why do those which feed on vegetables perspire so much? Horses and cows for example. We may often see them involved in a cloud of their own vapours, yea, almost covered with froth. 3. How can animals, whose natural food is vegetables, be kept alive and in health, in very cold climates, by purely animal food? Cows in Iceland and Norway, are fed in winter upon fish-bones." I would beg leave to ask, 4. Do the sweat-pores only, imbibe? Or those also, which serve for insensible perspiration?

15. Fat,* a whitish, oily substance, void of sense, is secreted from the blood, and lodged in small, oval, membraneous bags, which shoot out of the arteries. It is found in various parts, but chiefly under the skin, where, unless a man be emaciated, it runs co-extended with the skin over most parts of the body.

* A more important province is now assigned to the fat, than has been commonly considered as appertaining to its nature. It is now considered as the pabulum of animal heat, as the grand reservoir of that inflammable matter, which is essential to the elaboration of the blood in the veins, to prepare it for its regeneration in the lungs. Fat has been discovered by a course of chemical experiments to be capable of a great number of modifications, and combinations. It contains an acid, called the sebacic acid; which has the power of decomposing metalic substances, hence the reason, and process of salivation. It is very active in the principal secretions. It is largely concerned in the work of respiration, and excretion; it is a principle ingredient in the class of dissolvents, the gastric, pancreatic, and bilious humours; and its presence and influence are indispensible in the process of digestion, chylification, and the circulation of the blood. It yields the plentiful supply of oleaginous, and emollient liquors, with which the animate system abounds, and which are so essential to action, and the preservation of the parts. It enters into the whole class of stimulants, and seems the principal agent for a perfect assimilation. It supplies to the marrow, and bones, their plentiful lubrications and those smooth and slippery oils, which anoint their articulations, and prevent their friction. It forms the pulpy bed of the brain, the medula oblongata, and spinalis; and is employed in a concerte state, strengthened by, and enclosed in membraneous coatings, to form beds for the muscules and viscery. Fat in animals is correspondent in its properties and uses, to oil in vegetables; and is rendered highly combustible by the quantity of carbon, and hydrogen which it contains, and which appears to be absorbed through the integuments.

Fat is secerned from the arterial blood by the ADIPOSE GLANDS, and transmitted again from the membraneous cells to the blood through the veins. It seems to be a portion of the blood coagulated by the nitrous air mixed with it in the lungs. Artificial fat is made, by mixing, for some days, oil of olives with spirit of nitre. Hence divers animals grow fat in frosty weather, the air then abounding with nitre.

The uses of the fat are various; as to facilitate the motions of the muscles in all the parts, lessen their attrition against each other, and prevent a stiffness or rigidity; it fills up the intermediate spaces between the muscles in such a manner, with the cavities about many of the viscera, that it readily yields to their motions, and yet supports them when at rest; it serves as a stratum or bed to conduct and defend the vessels in their course to all parts; it gives an uniform extension to the skin, and serving as a cushion to ease the weight of the body in many parts, at the same time it renders the whole of a comely, agreeable shape: it probably, by returning and mixing with many of the humours, abates their acrimony; it has a principal share in forming the matter of the bile, and by transuding through the cartilaginous incrustations of the bones, it mixes with the articular liniment or synovia; also by exhaling in a living person from the mesentery, mesocolon, omentum, and round the kidnies, it lubricates the surfaces of the viscera with an oily, emollient vapour, and by interposing betwixt their integuments, prevents their growing one to another.

Yet too much fat is a real disease, which hinders the motion of the lungs, entangles the most active particles of the blood, and naturally creates dullness and heaviness. You may cure this, by following three plain rules; eat and drink little; sleep little; work much.

16. The fourth general integument is the PANNICULUS CARNOSUS, which in some parts is of a fleshy substance; in others, a mere membrane, lying just under the fat.

17. The dissimilar parts are composed of the similar. The chief of these is the HEAD. The cavity of the SKULL is nearly filled with a soft substance, termed in general, the BRAIN. But this is properly that part of it which lies forward. The hinder part, considerably smaller, is called the *cerebellum*. Under both, but chiefly the latter, and springing from the internal substance of both, is the *medulla oblongata*.

The skull is divided into two plates, one laid over the other. Between these is a spongeous substance, made of bony fibres detached from each plate. Hereby the skull is made not only lighter, but far less liable to fractures.

The skull is covered with a membrane called the PERICRANIUM. This has several holes, which give passage to the spinal marrow, the nerves, arteries, and veins. But these fill them so nicely, that nothing can pass into or out of the head, but through these vessels.

It is round, that it may contain the more; but a little depressed and longish, advancing out behind, and flatted on the sides, which contributes to the enlargement of the sight and hearing.

It is divided into pieces by four sutures. This makes it less liable to break, gives passage to the membranes of the pericranium, and vent to the matter of insensible perspiration.

18. All these are involved in two membranes, the inner called *pia mater*, extremely thin; and the outer, called *dura mater*, considerably harder and thicker. Where they involve the cerebellum, there is interposed between them the *arachnoides*, a very subtle and transparent membrane, which descending through the hinder part of the skull, together with them involves the whole spinal marrow.

19. The outer part of the brain, called the *cortex* or *bark*, is of an ashy or greyish colour. It is formed from the minute branches of the neighbouring arteries, which being wove together in the pia mater, enclose the inner part, ordinarily to the thickness of about half an inch.

It consists therefore of innumerable little glands, contiguous to each other (supposed to secern the animal spirits,) which are of themselves oval, but by their mutual pressure become angular, and run waving with each other.

The inner part, called the *medulla*, is white, and terminates in another medullary substance, very white and hard, called the *corpus callosum*. The medulla is thought to consist of fine tubes, which when collected into little bundles, and covered with membranes, are termed nerves.

20. To trace this a little farther. From every point of the outer brain arise minute fibres, which in their progress uniting together, are easily perceptible. These constitute the substance of the inner brain, and of the spinal marrow. In their farther progress they are distinguished by coats, detached from the two membranes of the brain, into several bundles called NERVES, resembling so many horse-tails, each wrapt up in a double tunic.

Several of these part from the rest, in the brain itself, of which there are ten pair: one on each side. From the spinal marrow there arise thirty pair more. All these, while within the skull or the spine, are pulpous; but afterwards harden, acquire a coat, and spread through the smallest points of the solid parts of the body. Their coats are every where furnished with blood-vessels, lymphatics, and vesicles of a very tight texture, which serve to collect, strengthen, and contract their fibres. And if we consider, 1. The great bulk of the brain, cerebellum, and spinal marrow, whereof the whole substance goes to constitute nerves, being continued into, and ending in them: 2. The great number of nerves distributed hence, throughout the

whole body: 3. That the brain and spinal marrow are the basis of an embryo, whence the other parts are afterwards formed; and lastly, that there is scarce any part of the body which does not feel or move; it may seem not altogether improbable, that all the solid parts of the body, are woven out of nervous fibres, and wholly consist of them.

21. The brain is divided into four ventricles. Near the rise of the fourth there is a round hole, over which is suspended the pineal gland, so called from its resembling the shape of a pine-apple. It is furnished with veins and arteries, and enclosed in a thin membrane, derived from the *pia mater*. Descartes imagined this to be the seat of the soul; but without any solid reason. Nor has any one yet been able to discover, what is the use of it. Is it such a reservoir of blood for extraordinary occasions, as some imagine the spleen to be?

The brain is abundantly bigger in proportion in man than in other animals. In other animals, it is commonly biggest, *cæteris paribus*, in those that have most sagacity.

There are in the brain multitudes of vessels, so extremely small, that if a globule of blood (a million of which exceed not a grain of sand in bigness) were divided into 500 parts, those parts would be too large to pass through them. And these vessels are as large in the brain of a sparrow as in that of an ox. Nor is there any difference between the brain of a large animal and a small, but that one contains far more of these vessels than the other. But the globules of the fluid passing through them are in all animals of the same size.

The outer part of a turkey's brain is a very clear and transparent, oily matter. Innumerable fine blood-vessels are spread though every part of this. And if a small part is cut, there flows out a small globule of pellucid fluid.

The brain is not absolutely necessary to animal life. Infants have been born, and lived some time without any. We have an authentic account from Paris, of a child that survived the birth four days, not only without a brain, but even a head: instead of which it had a mass of flesh, somewhat like liver. In 1673, a child was born alive without any brain, cerebellum, or medulla oblongata; the skull being solid: nor had it any communication with the spinal marrow. Mr. du Verney took out the brain and cerebellum of a pigeon: yet it lived and walked about. Mons. Chirac took out the brain of a dog; yet he lived. On taking out the cerebellum, he seemed dead; but revived when he blew into the lungs, and continued alive an hour. Nay there are many instances of insects living a long time, after their head is cut off. Hence it appears that the spinal marrow alone may, for a season, suffice both for life, sensation and motion.

Are there distinct provisions for the vital or spontaneous, and for the animal or voluntary actions? And does the cerebellum furnish

the heart, and other vital organs, with nerves, while the brain supplies the nerves, which go out to the organs of sense and voluntary motion? This is an elegant system, but is every where confuted by anatomy. From the cerebellum, the fifth pair of nerves is manifestly produced; but this goes to the tongue, to the muscles of the outward ear, of the eye, and of the nose, which are parts, all of them either moved by the will, or else destined to sensation. Again, from one and the same nerve there are vital branches sent to the heart and lungs, and others that are animal and voluntary to the larynx, or sensitive in the stomach. Lastly, the repeated accounts of injuries to the cerebellum, being so speedily fatal, are not altogether true; for that both wounds and scirrhosities of this part have been sustained without any fatality to the patient, may be affirmed by certain experience.

22. The EYES next offer themselves to our observation, guarded by the eye-lids, eye-lashes, and eye-brows. The eye-lids consist of the cuticle, the skin, a thin expansion of the *panniculus carnosus*, and an inward coat. A palisade of short, but stiff hairs grows out of their cartilaginous edge, both to break the too fierce impression of the rays of light, and to prevent any thing from getting into the eye, when open. These hairs only grow to a convenient length, and their points stand out of the way; those of the upper eye-lids being bent upward, and those of the lower, downward. Mean time the eye-brows hinder sweat, or any thing else which might be hurtful, from falling down from the forehead.

Both the eye-lids are moveable; but chiefly the upper. Animals which have hard eyes, as lobsters, need none, and therefore have no eye-lids. But most brutes have an additional eye-lid, called the nictitating membrane, which draws like a curtain, to wipe off what might incommode the eye. The monkey indeed has it not, as being furnished with hands like a man.

23. The eye can move upward, downward, to either side, and round, either toward the right, or left. For these six motions, six muscles are allotted, which spread their tendons far into the eye. At each inner corner of the eye, there is a gland with two or three ducts, which opening on the inner surface of the eye-lid, keep the eye-ball moist, to facilitate its motion. By these glands, tears also are secerned. The eye is connected with the surrounding bones by the *tunica adnata*, commonly called the white of the eye: in the midst of which is a large hole for the *tunica cornea*, through which the *iris* and *pupil* appear. The whole ball of the eye rises from the optic nerve, and is formed of three coats, propagated from it, and as many humours: two of which, have each a coat of its own also. The

eye therefore has five coats in all: three common, and two to contain their several humours.

24. The outermost coat, proceeding from the dura mater, and surrounding the whole eye, is termed the *sclerotica*: the forepart of it being transparent like horn, is thence stiled the *cornea*. This is more convex than the rest of the eye. It is composed of several parallel plates, which are nourished by many blood-vessels; but so fine as not to hinder the smallest rays of light. It has an exquisite sense, that on the least touch of any thing, the tears may be expressed, to wash off any filth, which by adhering to it might render it dim or cloudy. The rest of the sclerotica is opaque, and of the same colour with the dura mater.

The second coat is called the *uvea*. It is much thinner than the former, though thicker than the *pia mater*, from which it proceeds. In the forepart of it is a round hole, which with the chrystalline humour interposed, constitutes the pupil, surrounded by the *iris*, so named from its supposed resemblance to the colours of the rainbow. The third and inmost coat is termed the *retina*. It is extremely thin and soft, and darker coloured than the lower part of the optic nerve, of which it is a continuation.

"If it be questioned," says Dr. Haller, "whether the object is painted upon the retina, or upon the choroides; we answer, this late supposition is inconsistent with known observation, by which the retina is evidently a most sensible expansion of the nerve, while the choroides has only a few nerves, with small vessels, which are certainly blind. It is also opposed by the great variety of the choroides in different animals, while the constant uniformity of the retina is equally remarkable; to which add the black membrane, that is interposed betwixt the retina and choroides, in some kinds of fish. Finally, anatomy, demonstrates, that the choroides is seated in the blind part of the eye, but is of itself of a white colour."

25. The AQUEOUS HUMOUR, resembling the colour and consistence of water, lies in the forepart of the eye, just behind the cornea; its interior surface is convex; the other, a little concave. Whence this humour is derived we cannot tell; but its source must be plentiful: for if the coat containing it be so wounded that all the humour runs out, it needs only to keep the eye close for a season, and the wound will heal, and the humour recruit.

Indeed an eminent Italian affirms, that he has slit the pupil of divers animals, and squeezed out all the humours, and has afterwards restored them perfectly to sight; nay, that the eyes of many, instead of being damaged thereby, seemed more lively and vigorous than before.

The second humour, termed, improperly enough, the *chrystalline*, consists of many thousand filaments, tending from the circumference

to the centre, and closely woven together. It is a little convex before, and more behind. It serves to refract the rays of light, so that they may meet and form an image, on the bottom of the eye. It is set in the forepart of the vitreous humour, like a diamond in its collet, and is retained there by a membrane that surrounds it, thence called its *capsula*. It is toward the outside like a jelly; but toward the centre as hard as salt. The figure of the outer part is varied by a ligament annext, which can make it either more or less convex, or move it to or from the retina. And this is absolutely necessary in order to distinct vision: for as the rays of distinct objects diverge less than those of nearer objects, the chrystalline must either be made less convex, or be set farther from the retina.

When dried, it appears to consist of a vast number of thin, round scales, one upon another, 2000 of which have been counted in one chrystalline. Each of these consists of a single fibre, wound this way and that, in a stupendous manner, so as to run several courses, and meet in as many centres, and yet not interfere or cross in any place.

The third, which is termed the VITREOUS HUMOUR, is not unlike melted glass. It is covered with an exceeding thin coat. The forepart is concave, as receiving the chrytalline; the other side is convex.

The whole apparatus of the eye tends to this, that there be produced in the bottom of it, a distinct collection of all the rays, which proceeding from any point of an object, penetrate the chrystalline humour, that so an image of that object may be painted there. In order to this, the rays striking on the cornea, are reflected toward the perpendicular, and thus directed through the pupil to the chrystalline. Mean time the iris, contracting or dilating the pupil, admits fewer or more rays, as the object is more or less vivid.

Now the flatter the cornea is, the fewer rays does it collect and transmit to the chrystalline, and those more diverging. The rounder it is, the more rays does it collect and transmit, and those more converging. It is too flat in old men; it is too round in them that are short-sighted. The rays transmitted through the pupil to the chrystalline humour, are there refracted anew, collected and rendered converging, and those that come from the same point, are thrown in one point on the bottom of the eye. But if the chrystalline be too dense, the *focus*, or point wherein they unite, will be too near; if that be not dense enough, it will be too remote. And this is another cause of short-sightedness, or the contrary defect.

In all vision both the eyes are used at once. And both together (as any one will find upon trial) behold an object in another situation than either of them apart would do. Hence, a gentleman who had one of his eyes struck out, for some months after was apt to mistake

the situation of things; and when he attempted to pour liquors into phials, often poured them quite beside the neck of the phials.

Two eyes greatly contribute, if not to distinct, at least to extensive vision. When an object is placed at a moderate distance, by the means of both eyes we see a larger share of it than we possibly could with one; the right eye seeing a greater portion of its right side, and he left eye of its correspondent side. Thus both eyes in some measure see round the object; and it is this that gives it in nature, that bold *relievo*, or swelling, with which it appears; and which no painting, how exquisite soever, can attain to. The painter must be contented with shading on a flat surface; but the eyes, in observing nature, do not behold the shading only, but a part of the figure also, that lies behind those very shadings, which gives it that swelling, which painters can never fully imitate.

There is another defect, which either of the eyes, taken singly, would have, but which is corrected, by having the organ double. In either eye there is a point, which has no vision, so that if one of them only is employed in seeing, there is a part of the object to which it is always totally blind. This is that part of the optic nerve where its vein and artery run: that point of the object that is painted there, must continue unseen. To be convinced of this, we have only to try a very easy experiment. If we take three black patches, and stick them upon a white wall, about a foot distant from each other, each about as high as the eye that is to observe them; then retiring six or seven feet back, and shutting one eye, by trying some time, we shall find, that while we distinctly behold the black spots that are to the right and left, that which is in the middle remains totally unseen. When we bring that part of the eye, where the optic artery runs, to fall upon the object, it will become invisible. This defect, in either eye, is corrected by both, since the part of the object that is unseen by one, will be distinctly perceived by the other.

The form of the eye is the most commodious which can be imagined. It is fittest both to contain the humours within, and to receive the images of objects from without. Was it square, or of any multangular form, some of its parts would lie too far off, and some too nigh those lenticular humours, which by their refractions cause vision. But by means of this form, the humours are fitly placed to perform their office of refraction, and the li tle darkened cell neatly adapted to receive the image of the object.

Again: as it is necessary for the eye to move various ways, in order to adjust itself to various objects; so by this figure it is well prepared for such motions, and can with ease direct itself as occasion requires.

No less commodious is the situation of the eye: in the most emi-

nent part of the body, and near the most sensible part, the brain. By its eminence in the body, it can take in the more objects: and by its situation in the head, beside its nearness to the brain, it is most conveniently placed for defence and security. In the hand it might have been more ready for service: but to how many dangers would it have been exposed? The same may be said, as to its site in any other part but where it is. But the head is a part that seems contrived and made, chiefly for the use of the principal senses.

Some odd circumstances relative to the eyes, are related by a physician in the "Philosophical Transactions."

"A person had no visible disease in his eyes, yet could not see, unless he squeezed his nose with his fingers, or saddled it with narrow spectacles, and then he saw very well.

"A maid, 23 years old, could see very well, but no colour besides white or black. She could sometimes, in the greatest darkness, see to read almost a quarter of an hour.

"A saddler's daughter had an imposthume, which broke in the corner of her eyes; and out of it there came about thirty stones, as big as small pearls.

"A young man in Suffolk, about twenty years of age, has all the day a clear and strong sight. But when twilight comes, he is quite blind; nor can he see any thing at all, either by fire-light or candle-light. No glasses give him any help. He has been thus, ever since he can remember. This cloudiness comes gradually upon him, like a mist, as day light declines. It is just the same both in summer and winter, and at all times of the moon.

"When I was about sixty my sight was so decayed, that I could not distinguish men from women. I received no help from any glasses, till I took spectacles with the largest circles. Close to the upper semicircle on both sides, I cut the bone, and taking out the glasses, put black Spanish leather, taper-wise, into the emptied circles. These took in my whole eye at the wider end, and through the narrower end I can read the smallest print. Into this end I can only put my little finger not quite to the first joint. But this may be made wider or narrower, and longer or shorter, as best fits every eye.

"At first I could not bear them above two hours at a time; now I can use them above twelve hours in twenty-four. And they prove a great help to those who are purblind, who have weak eyes, or decayed with age. But for the purblind they must be made shorter: longer for eyes decayed with age.

"Instead of leather, they may be made of paper, coloured black and pasted on; and with inner folds to be drawn out, from one inch to three."

In some men the iris has a faculty of darting out light. Dr. Willis mentions one, who, after drinking wine plentifully, could see to read in the darkest night. And Pliny records of Tiberius Cæsar, that if he waked in the night, he could see every thing for awhile, as in the broad day-light. Dr. Briggs gives a parallel instance of a gentleman in Bedfordshire.

We find various substitutes for the use of the eyes, in many blind persons. In some the defect has been supplied, by an excellent gift of remembering what they had seen; in some by a delicate sense of smelling; in others, by a fine sense of hearing. So Richard Clutterbuck, of Redborough, in Gloucestershire, who was stone-blind, had so curious an ear, that he could hear the fine sand of an hour-glass fall. In some it has been supplied by an exquisite sense of feeling: so that the same Richard Clutterbuck was able to perform all sorts of curious works. He could not only take a watch in pieces, and set it together again, but could also make all sorts of stringed instruments of music. He likewise played on them by notes cut in their usual form, and set upon protuberant lines on the wood. Yet even this hardly came up to the skill of Van Eyck, the organist of Utrecht, who though he had been blind from two years old, played on all sorts of instruments.

Others have been able to take a face by the touch, and mould it in wax with the utmost exactness: as was the blind sculptor, who thus took the likeness of the duke de Bracciano, and made a marble statue of king Charles the First, extremely well.

26. But more than all this, some persons have been able even to distinguish colours by the touch. Peter of Maestricht, though perfectly blind, distinguished by his touch the different colours of cloth. John Vermaasen, of Utrecht, did the same; judging by the different degrees of roughness which he felt.

Yet blind persons, even though they distinguish them by the touch, have no idea of visible objects. Thus the gentleman couched by Dr. Chesselden: he had no idea of distance, but imagined all the objects he saw, touched his eyes, in the same manner as those he felt did his skin.

An extract from Dr. Chesselden's account of this person, will not be unacceptable to the curious.

"This young gentleman could, in a strong light, distinguish black, white, and scarlet. Yet the faint ideas he had of them before he was couched, did not suffice to make him know them after. He now thought scarlet the most beautiful of all colours. Of others, the most gay, were the most pleasing. But the first time he saw black, he was very uneasy; yet after a while he was reconciled to it. When he

first saw, no objects were so agreeable to him as those that were smooth and regular: although he knew not the shape of any thing, nor could distinguish one from another, either by its shape or size. Being told what those things were, whose forms he knew by feeling, he would carefully observe that he might know them again. Thus having often forgot which was the cat and which the dog, he was ashamed to ask; but catching the cat, which he knew by feeling, he looked at her stedfastly, and said, 'So puss, I shall know you another time.' He was surprised that the things or persons he liked best did not appear most agreeable to his sight, expecting that what was most pleasing to his other senses, would be so to his sight also.

"We thought he soon knew the nature of pictures; but found afterwards we were mistaken: for it was two months after the operation, before he discovered that they represented solid bodies. Even then he was no less surprised, expecting they would feel like the things they represented. He was amazed, that those parts, which by their light and shade appeared round and uneven, should feel like the rest, and asked, which was the lying sense, feeling or seeing? Being shewn his father's picture, drawn in miniature, and told what it was, he acknowledged the likeness; but asked, how it could be, that so large a face should be contained in so little room? Saying, it would have seemed as impossible to him, as to put a bushel of any thing into a pint. But even blindness, he observed, had this advantage, that he could go any where in the dark, better than those that could see. And after he was couched he did not lose it, but could go all about the house without a light. Every new object gave him new delight, such as he wanted words to express. He was particularly delighted when he first saw a large prospect, and called it a new kind of seeing. Being afterwards couched in his other eye, he said that objects appeared larger to this eye; though not so large as they did to the other, when it was newly couched. But looking on them with both eyes, they seemed twice as large as if he looked with that only."

27. I would beg leave to propose a few queries here, to which I have not found a satisfactory answer.

1. Why do we see things false with one eye? Particularly with regard to their situation.

2. How do the two eyes compound the rays of light, so as to see right?

3. Why do we not see all things double?

4. Since all things are painted upside down on the bottom of the eye; why do we not see them so?

28. We now proceed to the EAR, formed with exquisite wisdom, for the reception of sounds. The OUTWARD EAR consisting of an oval cartilage, externally convex, concave within, leads by various

windings to the *meatus auditorius*, which is first cartilaginous, and then bony. It is filled with a viscid matter, called the EAR-WAX, which is supplied from the vessels placed in the skin, surrounding the meatus, to hinder any hurtful animal from creeping into the ear. The meatus is closed within by a thin, dry, transparent membrane, affixt to a bony circle, which is called the *membrana tympani*. Behind it is that cavity of the *os petrosum*, which is termed the DRUM.

The outward ear has two parts, that which stands out from the head, called the AURICLE, and the narrow passage which enters the skull, called *meatus auditorius*.

The auricle is furrowed with divers winding canals, which receive and collect the various undulations of the air. They who have lost this, hear very confusedly, unless they use a trumpet, or form a cavity around the ear with their hands.

It is a wise provision, that the substance of the auricle is cartilaginous Had it been bone, it would have been troublesome, and might by many accidents have been broken off. If flesh, it would neither have remained expanded, nor so well have received or conveyed the sounds. Rather it would have blunted them, and retarded their progress into the organ. But being hard, and curiously smooth and winding, sounds find an easy passage, with a regular refraction, as in a well-built arch.

It is observable, that in infants in the womb, and newly-born, the *meatus auditorius* is close shut up, partly by the construction of the passage, and partly by a glutinous substance, whereby the drum is guarded against the water in the secundine, and against the injuries of the air, as soon as the infant is born.

It is remarkable, that in the ear of most, if not all animals, where the meatus auditorius is long enough to afford harbour to EAR-WIGS, or other insects, ear-wax is constantly to be found. But in birds, whose ears are covered with feathers, and where the drum lies but a little within the skull, no ear-wax is found, because none is necessary to the ears so well guarded, and so little tunnelled.

29. In this, besides a little branch of nerves, there are four little bones, two passages and two windows. Three of those bones, from some imagined resemblance, are styled the hammer, the anvil, and the staple: the fourth is termed the orbicular bone. These are fastened by strong ligaments to each other, and to the neighbouring parts. The passages go from the side of the drum: one of which, termed the labyrinth, by a very winding way, carries a part of the auditory nerve to the external muscles of the head. The other passes from the bottom of the drum to the palate; whereby not only air, if needful, may be received, but the defect of hearing, in some measure supplied by speaking to the mouth.

The LABYRINTH contains, besides the entrance, three bony semicircular cavities, and a bony canal, in the form of a screw, divided into two parts, from the top to the bottom. The labyrinth is lined throughout with a thin membrane, furnished with veins, arteries and nerves. And this membrane may not improbably be the organ of hearing.

The curious structure of the labyrinth and screw, tends to make the weakest sounds audible. Those canals, by their windings, contain large portions of the auditory nerve, upon every poin tof which, at once the sound being imprest, becomes audible; and by their narrowness the sounds are hindered from dilating, which must have weakened them proportionably.

The strength of the impression is likewise increased, by the elasticity of the sides of the bony canal; which receiving the first impulses of the air, reverberate them on the auditory nerve.

The AUDITORY NERVES are distributed, one to the ear, the other to the eye, tongue, and parts adjoining. By the distribution thereof to different parts, an admirable consent is established between them. Hence it is, that most animals hearing a strange sound, erect their ears to catch it, open their eyes, and are ready with their mouth, to shriek or call for help. A farther use of this nervous communication between the ear and the mouth, is, that the voice may correspond with the hearing, and be a kind of echo thereof: and that what is heard with one of these nerves, may readily be expressed by the help of the other.

And now, what less than an infinitely wise God, could contrive so fine an organ, and such a medium, so susceptible of every impression, that the sense of hearing hath occasion for, to empower all animals to express their meaning to each other, with endless variety? Yea, what less could form such an economy as that of music is? So that the medium conveys the melodious vibration of every animal voice or well tuned instrument, and the ear receives them, to allay the perturbations, and calm and cheer the heart of man!

Though the ear be the ordinary organ of hearing, yet it is not the only one. We may hear by the teeth: for if one end of a knife be applied to a spinnet, and the other held between the teeth, the music will be distinctly heard, though the ears be ever so closely stopped. Yet this is not properly by the teeth, but by the auditory nerve which passes from the drum to the palate.

In those who are born deaf, the eyes may in some measure serve in the place of ears. Some can understand what is said, by nicely observing the lips and tongue of the speaker: and may even accustom themselves to use their own, till they learn a kind of speech. Thus

a physician at Amsterdam, taught several children, born deaf, to understand what was said, and to give pertinent answers.

Mr. Goddy's daughter, of Geneva, lost her hearing at two years old. Yet by observing the lips of others, she had acquired many words, whereby she would talk whole days with those that could understand her. But she knew nothing of what was said, unless she saw the mouth of the speaker: so that if they wanted to speak to her in the night, they were obliged to light a candle. Only she knew what her sister said even in the dark, by laying her hand on her mouth.

But many deaf persons can hear, if a loud noise be made while you speak. Dr. Willis mentions one, who, if a drum was beat in the room, could hear very clearly. So that her husband hired a drummer for his servant, and by that means conversed with her daily.

30. The NOSTRILS are made not of flesh or bone, but of cartilage, the better to be kept open, and as occasion requires, to be dilated or contracted: for which purpose they are furnished with proper and curious muscles. The tubes therein growing narrower and narrower, lead into several little cells and winding cavities, covered with a soft coat, and provided with arteries, veins, glands and filaments of the olfactory nerves. This therefore is without all doubt the proper organ of smelling.

And forasmuch as it is by breathing, that the odorant particles are drawn in, the *laminæ* with which the upper part of the nose is barricaded, serve two excellent purposes; partly to prevent any thing hurtful from entering the breathing passages in our sleep, for which end likewise the hairs placed at the entrance of the nostrils serve, and partly to receive the divarications of the olfactory nerves, which are here thick spread, and by this means meet the smells entering with the breath.

Each of the CARTILAGINOUS LAMINÆ is divided into many others, folded into a spiral line. The *os cribosum* is made up of the extremities of these; the holes therein being the intervals between them. They are designed to uphold the inner tunic of the nose, which is folded round about together with these *laminæ*, that by its great expansion it may receive a greater number of the odorant particles. for the same reason, it is furnished with many small glands, which open into it, and moisten it with a slimy exudation, fitted to entangle and detain the subtile effluvia that touch it. And not only the number, but also the length of these laminæ, is of great use for the strength of smelling. For this purpose most beasts, which either hunt or distinguish their food by smell, have not their nose in the middle of their face like a man, but prolonged to the very end.

31. The TONGUE has for its basis that forked bone, called the *os*

gutturis. It consists of various muscles interwoven together, that it may be fit for various kinds of motion. To these are added very many small branches of nerves, which pass through the middle of it to the outside, and being gathered into little bundles constitute those *papillæ*, which makes its surface rough and uneven. Besides these, there appear also on the surface of the tongue, certain pointed fibres, not unlike the ends of birds' claws, inclining toward the basis of it, with which are interspersed innumerable salival glands. And all these are in their several ways subservient to the sense of tasting.

It has been generally supposed, that the tongue is essentially necessary to the formation of speech. But as sure as we have been of this, it is an entire mistake. A child in Essex, some years ago, had her tongue entirely cut out, by reason of an incurable canker. She was then three years old. Twenty years after, it was reported, that she was able to speak. To be satisfied hereof, Mr. Benjamin Boddington, Turkey-merchant, of Ipswich, with two other gentlemen, went to Wickham Market, where the young woman then lived, whose case they thus describe.

"We have this day been at Wickham Market, to satisfy ourselves concerning Margaret Cutting. We examined her mouth with the greatest exactness, but found no part of the tongue remaining; nor was there any *uvula*. The passage down the throat is a circular open hole, large enough to admit a small nutmeg.

"Notwithstanding this, she swallowed both solids and fluids, as well as we could do, and in the same manner. Yea, and she talked as fluently as other persons do. She pronounced letters and syllables very articulately, even those which seem necessary to require the help of the tongue, as d, l, t, w. She read to us in a book distinctly; she sings very prettily; nay, and she distinguishes tastes, and can tell the least difference either in taste or smell."

But is it possible to teach any one to speak, who has been deaf and dumb from his birth?

It is. Dr. Wallis taught such an one to speak: Mr. Daniel Whaley, of Northampton. He was present before the Royal Society, May 21, 1662, and did there pronounce, distinctly enough, such words as the company proposed to him; indeed not altogether with the usual tone, yet, so as easily to be understood. In a year, which was the time he stayed with D. Wallis, he read over great part of the English bible, and learned to express himself intelligibly in common affairs, to understand letters written to him, and to answer them. And in the presence of many foreigners, he has not only read English and Latin to them, but has pronounced the most difficult words in their languages, which they could propose to him.

The doctor has since done the same for Mr. Alexander Popham, a gentleman of a fair estate.

But we have an instance of dumbness cured in a shorter time, Henry Axford, son of Henry Axford, in the Devizes, at twenty-eight years of age, perceived a hoarseness, and in about six days became quite speechless; not only unable to speak articulately, but to utter the least sound with his tongue. His cold went off, but he remained absolutely speechless; and the advice of all the neighbouring physicians did not help him.

He continued totally dumb for four years, till in July, 1741, being at Stoke, in returning homeward at night, he fell from his horse, and was taken up and put to bed in a house on the road. He soon fell asleep, and dreamed he was fallen into a vessel of boiling wort. Struggling with all his might to call for help, he actually did call aloud, and recovered the use of his tongue from that moment, as perfectly as ever he had it in his life.

Perhaps, therefore, there is truth in that ancient story, concerning the son of king Crœsus: namely, having been dumb from his birth, he never had spoke at all, till in the battle, seeing a man ready to kill his father, his tongue was loosed, and he cried out aloud "soldier, spare the king!"

The time of cutting the teeth is usually from the seventh to the seventeenth month. It is commonly preceded by an itching of the gums, and by convulsions, fevers and looseness: most of which symptoms happen to birds also, upon moulting or casting their feathers. The seed of the teeth is a mucous matter, like the white of an egg, contained in the cells of the jaw-bone, which grows harder and bigger till it breaks through the gum.

The part of the tooth which stands out of the gum, is covered with a peculiar substance called ENAMEL. It is composed of an infinity of little tubes, which grow on the bone by their root. If any part of this be broken off, so that the bone be left bare, it grows carious; there being no bone which will bear the air.

We may farther observe, 1. That the teeth only, of all the bones, grow in length during a man's whole life; which is providentially designed to repair the waste that is continually made by attrition; 2. That the teeth are the only bones which are not covered with that exquisitely sensible membrane, the *periosteum;* 3. That they are harder and firmer than any other bone, that they may be more durable and fit to chew the most solid aliments; 4. That for their nourishment, there is a cavity contrived in each side of the jaw-bone, in which are lodged an artery, a vein, and a nerve which through smaller cavities send their twigs to every tooth; 5. That as infants are designed to live on milk for some months, they are so long with-

out any teeth: whereas animals that need them, have them sooner, and some are even born with them. 6. The different shape of the teeth is remarkable: the fore-teeth are formed broad, and with a thin and sharp edge, like chissels, to cut off a morsel from any solid food. The next, one on each side, are stronger, deeper-rooted, and more pointed, to tear tougher aliments; the rest are made flat and broad at top, and withal somewhat uneven, that thereby they may retain, grind and mix the aliment. 7. Because biting and chewing require much strength, partly in the teeth themselves, partly in the instruments that move the lower jaw, which alone is moveable: nature has given it strong muscles, which make it bear forcibly against the upper jaw: and has not only fixt each tooth in a distinct cavity, as in a close, strong and deep socket, but has given holdfasts to the several sorts of teeth, suitable to the stress that is to be laid upon them. So whereas the cutters and eye-teeth have only one root, the grinders, designed for harder work, have three: in the upper jaw often four, because they are pendulous, and the substance of the jaw somewhat softer. 8. The situation of the teeth is most convenient. The grinders are behind, near the centre of motion, because chewing requires a considerable force: the cutters before, ready for their easier work.

32. The PALATE is of a bony substance, a little concave, and clothed with a thick membrane, which has the same kind of nervous *papillæ* and small glands, that are seen in the surface of the tongue: and hence it is qualified to assist the taste as well as the speech.

It would be endless to specify the curious mechanism of all the parts that concur to form the voice; however, let us note two things: 1. There are thirteen muscles provided for moving the five cartilages of the wind-pipe. 2. It is amazing that the *glottis* (the upper part of the wind-pipe,) can so exquisitely contract or dilate itself, to form all notes. "Suppose," says Dr. Keil, "the greatest distance of the two sides of the *glottis* to be one-tenth of an inch, in sounding twelve notes, to which the voice easily reaches, this line must be divided into twelve parts, each of which gives the aperture requisite for such a note. But if we consider the subdivision of notes into which the voice can run, the motion of the sides of the glottis is still vastly nicer: for if of two chords, sounding exactly unisons, one be shortened but the two-thousandth part of its length, a just ear will perceive the disagreement, and a good voice will sound the difference; and yet this is only the one-hundredth and ninety-sixth part of a note. But suppose the voice can divide only into a hundred parts, it follows, that the different apertures of this glottis, actually divide the tenth part of an inch, into twelve hundred parts, the effect of each of which produces a sensible alteration upon a good ear."

33. The UVULA is a round, oblong, fleshy substance, suspended near the passage from the mouth into the nostrils, and probably designed to hinder the cold air from rushing too fast into the lungs, as well as to prevent the food we swallow from regurgitating into the nostrils.

The TONSILS, or almonds of the ear, are two small glands, placed at the root of the tongue, which supply an humour, to keep the mouth and the tongue continually moist.

The WIND-PIPE is wonderful in its conformation, because continual respiration is necessary; it is made with *annular cartilages*, to keep it constantly open, that its sides may not fall together; and lest, when we swallow, any particle of food should fall in, which might cause convulsions, or even death, it has a strong shutter, or lid, called the *epiglottis*, which, whenever we eat or drink, falls down of itself, and covers it close, so that no crum or drop can enter. It is for the more convenient bending of our necks, that the wind-pipe is not made of one entire continued cartilage, but of many circular ones.

What is farther remarkable in these cartilages is, that all the way where they are contiguous to the gullet, they are membranous, to give an easy passage to the food; but after that, they are, some completely round, some triangular. Another thing observable is, in the wind-pipe, the cartilages run parallel to each other; but, in the lungs, the lower parts of the superior cartilages, receive the upper parts of the inferior: hereby enabling them to contract themselves in expiration, and to dilate in inspiration.

34. The HAIRS are all hollow. The root of each hair is fixt in a mucous globule, of an oval figure, which often adheres to it, when it is pulled up by the root. They are jointed like a reed or cane, and shoot out into small branches. They serve not only for a covering, but also for the excretion and expiration of an oily matter.

Every hair does properly live, and receive nourishment like the other parts. The roots do not turn white or grey in age, any sooner than the extremes; but the whole of each hair changes colour at once. Or, to speak more properly, the hairs of another colour fall off, and white ones grow in their place.

But extreme fear may turn the hair grey, or even white in a short space. So it was in that famous instance some years ago. A nobleman, in Germany, was condemned to die, and ordered for execution in the morning. During the night, in ten or twelve hours time, all his hair turned white as flax. The emperor being informed of this, said, "he has suffered enough;" and pardoned him.

Since that time, there has been an instance of one of our own countrymen, who being shipwrecked, saved himself on a small rock, sur-

rounded by the sea. A boat took him off after he had stayed there four hours. But in that space his hair was turned quite white.

Perhaps a still stranger instance of this kind is related in the duke of Sully's memoirs. "Henry IV. told the marquis De la Force, that the moment he was informed Henry III. had published an edict (in July, 1585), ordering all the Hugonots either to go to mass, or to abandon the kingdom in six months, his mustaches turned suddenly white on that side of his face which he supported with his hand."

Its life is a peculiar kind, and approaches to the nature of vegetation.* Hairs grow much as plants grow out of the earth, or as some plants grow upon others: from which they draw their nourishment, and yet each has its life distinct from the other. So hair derives its food from some juices in the body; but not from the nutricious juices. Accordingly the hair may live and grow, while the body is starved to death.

That hair may grow, merely as an excrescence of the vegetable kind, appears from that memorable case recited by Mr. Hook, of a body which having been buried forty-three years, was found in a manner wholly converted into hair. The woman was buried in a coffin of wood, and lay the lowest of three in the same grave. The others being removed, and this coffin appearing, it was observed that much hair came through the clefts of it: on removing the lid, the whole appeared a very surprising sight. There was the whole figure of the corpse, exhibiting the eyes, mouth, ears and every part. But from the crown of the head, even to the sole of the foot, it was covered over with a very thick set hair; long and much curled. The people, amazed at this appearance, went to touch the corpse; but the shape fell away as it was handled, leaving only a quantity of shapeless hair; but neither flesh nor bones, only a small part of the great toe of the right foot.

Each hair consists of several smaller ones, wrapt up in one common covering. They send out branches at the joints. The root lies

* Hairs appear to be perfect vegetable bodies, consisting of roots, a trunk, and branches, and performing all the functions of vegetation. The whole of the outward covering of the body called the skin, may be considered as analagous to a bog, or turf, wherein the incrustations are effected by the intertwining of innumerable fibrous roots, inserted in the lamina of the skin; and which vegetate, and are nourished in it. It has been satisfactorily ascertained that vegetables absorb mephitic air, and emit vital air; and that animals respire vital air and emit mephitic air; and that thus the labours of the animal and vegetable kingdoms are directed to reciprocal nourishment and support. This has led some to reject the doctrine of absorption by the integuments, but it would appear in numerous instances, that the double operation is carried on in the animate system, that the hairs serve as conductors to vegetable absorption; and that the glandular system is abundantly regulated by the vegetable influence.

pretty deep in the skin: and by this they imbibe their proper nourishment, from the adjacent humours. Their extremes also split into two or three branches, especially if they are very dry, or too long. So that what appears a single hair to the naked eye, to the microscope appears a brush. They are grey on the fore part of the head first, particularly about the temples: the back part affords them nourishment longer. For the same reason they fall from the crown of the head first. Their thickness depends on the size of the pores they issue from: if these are small, the hair is fine. If the pores be straight, the hairs are straight: if oblique or sinuous, the hairs are curled.

All hairs appear round. But the miscroscope discovers some of them to be square, others triangular; which diversity of figure arises merely from the diversity of the pores. Their length depends on the quantity of humours proper to feed them, and their colour on the quality. And hence the colour usually differs in the different stages of life.

The hair of a mouse is a transparent tube, with a pith of small fibres convolved, running in some hairs spirally, in some transversely, in others from top to bottom.

The NAILS are of the nature and fabric of the cuticle, like which, they are also insensible, and renewable, after being cut or fallen off. They are placed upon the backs of the ends of the fingers and toes, which they support to make a due resistance in the apprehension of objects, having the nervous papillary bodies, that serve the organ of touch, placed under their lower surface. They arise with a square root, intermixed with the periosteum, a little before the last joints, from betwixt the outer and inner stratum of the skin, and, passing on soft, go out by a lunar cleft in the external plate of the skin, where the cuticle returns back, and enters into a close adhesion with the root of the nail, together with which it is extended as an outer covering.

35. We proceed to the middle cavity of the body. Herein the principal part is the HEART, consisting of a strong tendon, extended obliquely from the basis or broader part, to the cone, into which the fleshy fibres are inserted, in an elegant series, with a spiral bending, one half opposite to, and crossing the other; by which means the grand muscle is admirably fitted both to receive and to propel the blood. It has two great cavities, usually termed VENTRICLES of the heart. They are divided from each other by an intermediate part called the *septum*, constituted by the same fibres, which is convex on the side next the right ventricle, and concave on the other. The *vena cava* is inserted in the right ventricle, and two inches from its insertion, divides into the upper and lower. The former brings the

blood into it from the upper: the latter, from the lower parts of the body. The PULMONARY ARTERY carries the blood from that ventricle into the lungs, which the PULMONARY VEIN brings from thence into the left ventricle. At the upper side of these veins, there is added to each ventricle, a kind of purse called the AURICLE, which is a hollow muscle of the same structure as the heart, in order to stay the blood, that it pour not too violently into the ventricle. Before the orifices of the veins of the heart, there are triangular valves, and semilunar in the orifices of the arteries, to hinder the reflux of the blood, from the ventricles into the veins, and from the arteries into the ventricles. In a healthy person, the heart contracts little less than five thousand times in an hour.

36. The heart is covered with a fine membrane; and near the base of it, on the outside, there is a little fat, probably designed to facilitate its motion. It is placed near the middle of the breast; only its cone inclines a little to the left. It hangs by its base on veins and arteries, communicating with all parts of the body. The other part of it is loose in the PERICARDIUM, that it may be the more commodiously constringed and dilated. The pericardium is a kind of membrane, that like a kind of purse, loosely encloses the heart. The shape of it is suited to that of the heart, and it contains a thin, saltish, reddish humour, exuding from the arteries.

The brain has an alternate contraction and dilation, answering those of the heart. It is highly probable, the weight of the atmosphere is the counterpoise to the contractile force of the heart. That of the brain being not near so strong, does not need so strong a counterpoise.

In the basis of the heart, in some animals, there is a bone frequently found. Such an one was found in the heart of pope Urban. Probably it was only the tendons of the heart ossified.

Wounds of the heart are not always so immediately mortal as is generally supposed. A soldier was brought into one of the hospitals in Paris, with a wound in the upper part of the left breast. He seemed very well for three days: but on the fourth was taken with a fever and difficulty of breathing, and died on the tenth. On opening the body, it was found the sword had pierced the pericardium, traversed the right ventricle of the heart in its lower part, pierced the pericardium on the opposite side, and gone through the diaphragm, and an inch deep into liver.

37. The heart is placed in the middle of the LUNGS, which consist of two parts, the right and left lobe. Each of these is divided into two other lobes; one of these frequently into three, sometimes into four, by fissures, sometimes deeper, sometimes shallower, running from

the interior margin towards the back part. The lungs are divided into cells, which are no other than expansions of the small branches of the *trachea* or wind-pipe. And there is an easy passage from one branch into many cells, and again into it from them all. The upper part of the *trachea* opens into the mouth; the lower, divided into two branches, shoots out into various ramifications, which are termed *bronchia*. And these little canals running on, constitute the lungs, whose cells are wonderfully connected together, and intermixed with numberless branches of veins and arteries.

The upper end of the trachea is called the LARYNX. At the fourth vertebre of the back, it divides and enters the lungs. Its cartilages, ranged at small and equal distances, are smaller and smaller as they approach the lungs.

These cartilages have two membranes. The external, composed of circular fibres, covers the whole *trachea*. That which lines it within, consists of three distinct membranes; the first woven of two orders of fibres, part longitudinal, to shorten it by drawing the cartilages together; part circular, to contract them. Both these together, with the external membrane, assist in breathing, coughing, and varying the tone of voice. The second membrane is glandulous; and its glands opening into the cavity of the trachea, separate a liquor which moistens and defends it from the acrimony of the air. The third is a net work of nerves, veins and arteries.

The organs which form the voice of man, have not been accurately observed by the ancients. As the trachea bears some resemblance to a flute, they considered the voice according to the sounds of that instrument. Mr. Dodart was the first who shewed the glottis to be the chief organ in producing it, and considered it both as a string and wind instrument, far more perfect than any which art can produce.

The organs which form the various voices of other animals, are likewise worthy of our attention. Those of each species have peculiar sounds, whereby they understand each other. Wherein do these organs resemble ours? and wherein do they differ?

The human voice is almost wholly formed by the glottis, and various tones are produced by the various modifications of it. But all these depend on one only: the separation and junction of its lips. This comprehends two circumstances, the one capital and primitive? the other, a consequence of it. The first is, that the lips are more and more bent, from the lowest to the highest note. The second, that the more they bend, the nearer they draw to each other. It follows from the first, that their vibrations will be more frequent, as they come nearer the highest tone, and that the voice will be exact when they are equally bent, and the reverse when unequally: which corresponds perfectly well with the nature of stringed instruments. It follows

from the second, that the higher the tone, the nearer they draw to each other. And this agrees perfectly with those wind instruments which are governed by reeds. From these simple, and almost perceptible variations, proceed the infinite variety of sounds.

In most quadrupeds too the glottis is the principal organ of the voice. So it is in cats, sheep, and several others. But many have something more than a glottis; as horses, asses, mules, and swine. Some of these have also a tendinous membrane, which concurs in forming the voice. Others have several membranes; others a kind of bag, which in some are membranous, and in others bony. Others have both membranes and bags. Others, lastly, have in their larynx a kind of cavity or drum, which assists them in uttering very strong and long continued notes.

All sounds are produced by a swift succession of vibrations, from the particles of sonorous bodies, which agitate the air. But the vibrations of the lips of the glottis would not suffice to produce the neighing of a horse. This begins by more or less acute interrupted tones, accompanied by quaverings, and ends by tones more or less grave, which is performed by jerks. This second part is done by the lips of the glottis; the other chiefly by a small, elastic membrane. This is tendinous, very thin, of a triangular figure, and lies flat on each extremity of the lips of the glottis. As it adheres but loosely to these, it can easily flutter up and down; and it is the play of the membrane up and down which produces the acute sounds of neighing. These are more or less acute, as the membrane is more or less thin, and its adhesion more or less slack. The grave sounds that conclude the neighing, are excited by the fluttering of the thick strings which form the lips of the glottis.

The hoarse sound of the ass's voice, is not so much produced by the lips of the glottis, as by a tendinous part which adheres loosely on the aperture of a kind of drum, situate under the extremity of the lips of the glottis: above which are also found two large and thick bags, one on the right, the other on the left. Each of these has a roundish aperture, cut much like the stopple of an organ.

Such are the organs which form this amazing sound. A kind of drum is the principal; and the two bags above the lips of the glottis are the main auxiliaries; while those lips, as plain experiments shew, contribute very little thereto. The mule's voice much resembles that of his sire, and is formed by much the same organs; the drum, of so singular a composition, being found in mules also.

There is another animal which affords us a particular disposition of the vocal organs. This is the hog; whose shrill cries are more insupportable than his usual grunting. Yet neither are these excited by the lips of the glottis, but by the fluttering of two large mem-

branous bags, situated on each side, above the lips of the glottis. What is most remarkable is, that each lid is cloven, almost its whole length. By this cleft each lip has a communication with the bag belonging to it; and the motions of these bags produce most of the sounds peculiar to this animal.

Though the voice of birds bears a nearer resemblance to ours, than that of quadrupeds, yet their organs have far less resemblance to ours, and contain a greater number of singularities. They, like us, have a glottis at the top of the trachea; but they have another at the bottom of it, which much contributes both to the strengthening and modifying of their voice. These have different membranes more or less fine, more or less bent, and in a variety of positions. In some birds, as in geese, there are four of these, figured and disposed like the reeds in hautboys.

With regard to the human voice, an ingenious man observes: "Sitting in company, I chanced to take notice, that in ordinary discourse, all that is spoke, is spoken in perfect notes; and that some of the company used eighths, some fifths, and others thirds. I observed likewise of him whose speech was the most pleasing, that all the tones he used, consisted either of concords, or of such discords as made up harmony."

Cutting the *trachea* was long reputed mortal: but it is now usual to open it in dangerous quinsies. This, physicians were at first encouraged to do, from the case of a Cornish gentleman, who had his wind-pipe quite cut through, and yet was cured and lived several years after.

38. In order to the admission and expulsion of the air by the lungs, it is necessary the breast should be contracted and dilated. This end is served by the bony part of the THORAX, the INTERCOSTAL muscles, and the DIAPHRAGM, a broad, muscular, part, reaching across the breast, and dividing the middle from the lower cavity. It runs obliquely from the *sternon* and ribs before, to the *vertebræ* of the loins behind.

39. The whole thorax is covered on the inside with a firm, white membrane, called the PLEURA. It is double throughout, consisting of two folds; the innermost whereof has a smooth surface, that it may not hurt the tender substance of the lungs; the surface of the outer is rough and uneven. From the pleura rises the MEDIASTINUM, which is a double membrane, that divides the lungs and the cavity of the thorax lengthways into two parts.

40. On the slightest observation we cannot but acknowledge, the consummate wisdom wherewith the external parts of the middle cavity are formed, for beauty as well as for the defence of the internal. This is commodiously connected with the head, by the neck

The BREAST, or forepart of the thorax, which begins at the throat, and ends at the STERNON, or breast-bone, is an admirable guard to the noblest parts. To the same end serve the SHOULDER-BLADES and the BACK-BONE, as well as to support the whole fabric.

The BREASTS consist of numberless oval glands, intermixed with globular vessels of fat. Their ducts, as they approach the nipple, unite together, till they form eight or more small pipes, communicating with each other by cross canals, which are of great use, when some of them happen to be obstructed. These tubes are in some parts narrower, in some wider, so as to form cells, which hinder the efflux of the milk. The PAPS consist chiefly of the concurrence of these tubes, but with a glandulous substance intermixt. There are likewise joined herewith abundance of fibres, from the external teguments of the breasts, by means of which the tubes are constringed, and the motion of the milk is modified.

In virgins, the glands of the breasts are so contracted, that no blood can enter them. But when the womb swells with the fœtus, and compresses the descending trunk of the great artery, the blood forces its way into them. They admit thicker and thicker serum, till after the birth, they run with a thick milk.

It is more difficult to account for the milk which some men have in considerable plenty. Thus in the year 1684, a countryman, called Billardino di Billo, living in a village near Nocœra, in Umbria, when his wife was dead, took the child and put the nipples of his breasts into its mouth, invited it to suck; which the infant did, and after several times drawing, fetched some milk. After a while it brought down the milk so plentifully, as to nourish it for many months till it was weaned.

Almost as strange is the following account: "One informing me of an old woman that gave suck, I went to the house in Tottenham-court-road. Her name is Elizabeth Bryan. She is in the 68th year of her age, and has not borne a child for many years: her face is withered, her cheeks and mouth sunk in: but her breasts are full, fair and void of wrinkles. About four years ago, her daughter was obliged to leave an infant she gave suck to in the care of her mother. The old woman finding the child froward for want of the breast, applied it to her own. Having done this several times, her son thought the child seemed to swallow, and begged his mother, he might try if she had not milk; it soon appeared she had; and she then continued to suckle the child in earnest. Two years after, her daughter had another child; on which the grandmother weaned the first and suckled the second. Both the children are healthy, plump and firm in flesh, and as brisk and lively as can be desired."

41. In the lower cavity first occurs the STOMACH, with the OESOPHAGUS or GULLET, which reaches to it from the mouth. The right orifice, called the *pylorus*, transmits the digested food to the intestines. It is narrower than the other, as being designed to transmit nothing till it is reduced to a kind of liquid. And it goes by a long and oblique descent into the duodenum, that the chyle may not pass out, either too swiftly or too slowly.

The upper opening of the stomach, is compressed in such a manner by the lower muscle of the diaphragm, in every inspiration, as to confine the food within the stomach, and direct it in every respiration, towards the pylorus. By this means this orifice of the stomach, is so closely shut, as to confine even wind or vapours within the cavity of a healthy stomach, from whence they never escape but by a morbid affection.

The fabric of the stomach answers to that of the oesophagus, of which it is an expansion. 1. The outmost coat is from the peritoneum, of considerable strength, so as to limit the extension of the rest, and afford a support to the subjacent muscular fibres. 2. The cellular coat lies immediately under the former, whence the outer and muscular tunic closely cohere together; in this substance the larger branches of the vessels are distributed. Next in order appears, 3. the muscular coat. Here the longitudinal fibres of the oesophagus, coming to the stomach are detached one from another in all directions.

Immediately under the muscular fibres, follows, 4. another cellular stratum, larger than the outermost, softer, more easily inflatible, and consisting of larger vessicles than what we usually observe, even in the intestines. Within this cellular substance are spread the small vessels, which coming from the larger branches of the stomach, enter through its muscular coat, and spread internally after the manner of a plexus. Under this lies, 5. the nervous coat, which is thick, white and firm, and makes up the true substance of the stomach itself; and this is again lined internally with a third cellular stratum, whose vascular net-work is much more minute than that of the former, from whence it is derived. Immediately within this lies, 6. the villous or velvet-like coat, that lines the cavity of the stomach itself, contiguous with the external cuticle, like which it is renewable, but of a soft mucous texture, and extended into a very short pile, like that of the tongue, only less conspicuous, and folded into large plates.

42. The INTESTINES are a continuation of the alimentary tube from the pylorus, wound together in various wreaths, yet without confusion, and to keep them in their situation, fastened together by the MESENTERY, a strong membrane, which fastens them also to the back. The intestinal duct is really but one; but because the parts of it dif-

fer in figure and use, the upper part of it, divided into the *duodenum*, *jejunum*, and *ileum*, is termed the SMALL GUTS: the lower part divided into the *cœcum*, *colon*, and *rectum*, is called the GREAT GUTS. All these are full of turnings and windings, especially the small, that the more subtle part of the chyle, both through the length and narrowness of the passage, and the agitation of the intestines, may enter the lacteal veins, and pass from thence into the receptacle of the chyle.

When the intestines are separated from the mesentery, they are usually six times as long as the man. They have all a kind of vermicular motion, called the PERISTALTIC MOTION, from the stomach downwards; and are lubricated with much fat, especially the great ones, whose surface being more uneven, and their contents less fluid, they need somewhat more to make them slide easily.

Likewise from the exhaling arteries distils a thin, watery liquor, the cavity of the intestines, not at all acid, but like the juice of the stomach; the quantity of which liquor may be computed from the large extent of all the excretory orifices, and from the section of the secretory artery, a larger than which, we see no where in the body.

The duodenum, so called because it is usually ten or twelve inches long, receives the gall and pancreatic juice, which are here mixt with the chyle. The jejunum is so termed, because it is generally more empty than the rest. This may be occasioned partly by its capacity, which gives a free passage to its contents; partly to its irritation through the bile, which falls in a little above it. It takes up almost the whole umbilical region, and is usually twelve or thirteen hands long. The ileum, situate below the navel, fills the ilia with its numerous convolutions. It is much the longest of all the intestines, generally one and twenty hands long. In both this and the jejunum the inner coat is much wrinkled, and lies in loose folds. They are formed, as the folds of the stomach, only by the inner coat being larger than the outer.

The first of the great guts, called the *cœcum*, is literally inserted at the upper end of the *colon*. It is not perforated at the other end, but hangs to it like the finger of a glove, and is three or four inches long. In new-born children, and in beasts it is found full of excrements; but in adults it frequently hangs like a worm. In a fœtus it is doubtless a receptacle of the fæces, during the time it does not discharge by stool. And may it not occasionally serve the same end in adults? Perhaps in those animals wherein it is very large, it may likewise serve as a kind of second stomach. But it is not absolutely necessary. The cœcum of a dog has been cut out without any perceivable prejudice.

The colon is the largest of the great guts. It runs into various circumvolutions from the cœcum to the rectum. It has many cavities,

formed by two ligaments, running on each side of it, opposite to each other the whole length, and as it were guiding it at certain distances. The rectum, which reaches from the *os sacrum* to the *anus*, is usually about a hand and a half long.

43. The LACTEAL VEINS, which are of a whitish colour, are in all the intestines, small and great, and receive the chyle by imperceptible passages, throughout the whole canal. And for this end the food remains so long in the intestines, and is carried through various windings, that whatsoever of nourishment it contains, may be expressed before it leaves the body.

44. The intestines are covered with the OMENTUM or CAWL, which is contained within the PERITONEUM, a very thin, soft, double membrane, and wholly consists of little bags of fat. Its use is to keep the intestines warm; to promote their peristaltic motion by lubricating them with its oily substance: by following them in their doublings and windings, to serve them as a bolster, to slide upon, and by filling up their hollows, to prevent their being too much distended by flatulencies; yet giving way to them when filled with aliments.

Under the stomach behind lies the PANCREAS, extended towards the spleen, which transmits to the intestines a liquor of the nature of spittle, helping to dissolve the food.

45. Under the diaphragm, on the right side, lies the LIVER, whence it extends over the right part of the stomach, below the sternum, toward the left, growing gradually smaller, that it may not hinder the distention of the stomach. It consists partly of gall-ducts, partly of fine ramifications of the vena porta. The blood contained in these, deposits oily particles in the ducts, and then returns, chiefly through the vena cava, to the heart. It is thus the BILE is secreted, for which purpose the GALL-BLADDER also is designed. This both receives and retains the bile, by which delay the power of it is greatly heightened. Part of the bile is conveyed to the intestines by the HEPATIC DUCT, which pours it into the *ductus choledochus*. Part goes first into the gall-bladder, thence into the ductus choledochus, and then into the duodenum.

The principal use of the bile is, to absterge and stimulate the intestines, to assimilate crude things to things concocted, to bruise and blunt sharp and saline particles, to divide those that are coagulated: to excite appetite, to open the passages for the chyle, and where need is, act the part of a ferment.

46. The SPLEEN is an elegant net-work of numberless vessels, enclosed in a double membrane: it is placed on the left side, between the short ribs and the stomach. Some suppose it to secrete a peculiar juice, which passes with the blood through the vena porta. Others imagine it to be a kind of reservoir, wherein on extraordinary

occasions, that blood may be received, which would otherwise oppress the viscera and disturb the animal functions.

47. On the muscles of the loins on each side lie the KIDNEYS, to separate from the blood that part of the serum which is superfluous, and would be hurtful were it retained in the habit. This is carried by the URETERS into the bladder, which is placed in the lowest part of the belly. What remains of the blood is conveyed to the heart by the veins and lymphatic vessels.

The bladder is composed of three coats: the first is an extension of the peritoneum; the second consists of muscular fibres; the third is both glandulous and nervous, and full of wrinkles, that it may be capable of contraction and dilatation. Its glands separate a slimy matter, which defends the bladder from the acrimony of the urine. The involuntary emission of this is prevented by a small muscle which goes round the neck of the bladder.

48. We proceed to the LIMBS. The HAND, physically speaking, is divided into the ARM, the CUBIT, and the HAND, properly so called. In this there are twelve bones, besides fifteen in the fingers, all oblong, slender, hollow, and so fitly joined together by ligaments, so wonderfully provided with various muscles, adapted to so many different motions, that the hand alone gives us an abundant argument of the admirable wisdom of God.

Is there any possibility, that the want of so necessary an instrument as the arm should be supplied? One would think it impossible. But it is not: such is the amazing power of God! James Walker was born in 1718, in Ireland, in the parish of Hillsborough. His mother could not be delivered, till the surgeon totally separated the arms of the child from the body Nevertheless he lived, and in the room of his arms, had little protuberances that appeared as stumps. He grew to be six feet high slender and active. "He sits a saddle," says an eye-witness, "upright and firm, will ride forty miles a day to a fair, and deals in buying and selling horses, which he dresses and curries without much apparent difficulty, holding the curry-comb between his chin and shoulders. The same way he holds the goad in driving the plough, and the spade when he digs. He throws a stone from the top of his foot with greater force than most men can with their hand, and seldom fails to hit his mark. He mounts a horse without any assistance, and shuffling the bridle over his head, till he gets it on his shoulders, guiding his horse with as little fear, and as much skill as most men."

49. The THIGH consists of one bone, the largest and longest in the whole body. It is a little crooked, bending forward before, that there may be more room for the muscles. The bones of the LEG are two, distant from each other in the middle, but joined together at each

end. They are nearly of the same length, but the inner is much thicker than the outer. The bones of the foot are twelve, besides fourteen in the TOES; which like those in the hands, art most aptly connected by ligaments, and fitted with muscles of various kinds, serving for equally various motions.

50. Thus far we have spoken concerning the SOLID PARTS of the body. Among the *fluid* are usually reckoned the ANIMAL SPIRITS, supposed to be secreted in the brain, to flow through the nerves, and to be the instruments of sense and motion.

"But are the nerves in general hollow canals, which contain a circulating fluid? Or are they solid threads, which being highly elastic, vibrate variously to occasion various sensations?"* The latter sup-

* The nerves are now ascertained, by the most decisive experiments, to be conductors of the galvanic electricity. This is a species of electricity different from ærial electricity, as is fully demonstrated by its different effects. It is more located, and confined than ærial electricity; it seems to originate peculiarly in a fermentative process of metallic substances; it is limited in its relations, but most strikingly adapted to the nervous sensibility, hence it has been denominated by different experimentalists, *animal electricity*, the *nervous fluid*, *animal spirits*, &c. The nerves are unquestionably the organs of sensibility, as the veins and arteries are for the elaboration and circulation of the blood, as is largely exemplified in the experiments made by the commissioners, appointed at Paris, for investigating the effects of the galvanic fluid on the muscles. The brain, the medula oblongata, and spinal marrow are the grand reservoirs of this effluvia, whence all the nerves originate. The nerves are a continuation of the same matter, and of the same susceptibility: only more compact in their substance, and twisted into threads, or rods, and sent in all directions through the body, to be conductors of the subtle fluid, which flies with the rapidity of lightning, and excites instant and universal sympathy throughout the whole animate system.

In the arrangement of our ideas we are too apt to lose sight of those gradations, with which nature enshrouds her operations: and we naturally consider as mysterious every thing which we cannot fully comprehend, and this indeed is what constitutes mystery. Very many things have once appeared mysterious, which after subsequent discovery, or developement, have been considered equally simple. This was the case with that description of air, which is essential to combustion, and the support of flame. Until Dr. Priestly in the year 1774 by a course of experiments which were equally successful and happy, discovered the composition of air, and found that there was a portion of it, which was essential to combustion and the support of flame: which consisted in quantity of about one-fourth of the common air. This he termed phlogistic, but in the new nomenclature, it is termed oxygenic air. On this important discovery the mystery vanished at once, and it was ranked among the simple processes of nature. We can handle and subject to easy experiment, the more gross and ponderous substances in nature, and so far possess ourselves of scientific data. But nature travels on from these to such degrees of subtlety and refinement, that it is with the utmost difficulty we can arrest her fugitive bodies in their course. And some there are that the utmost application of art can never touch, can never intercept. But very lately animal sensibility has been ascertained to be a species of electricity, and the truth of this has been amply illustrated, by numerous experiments on galvanism. This was a

position is wholly overthrown by the phenomena of wounded nerves. A nerve cut asunder does not retract its divided extremities, but becomes rather longer, extruding its medulla into a round tubercle. Again, were it elastic, it should be composed of hard fibres, having

wonderful discovery, and tends to shew in an indisputable manner the nature and office of the nerves.

That the nerves are the organs of sensibility, is amply demonstrated by experiment. If a nerve be cut which communicates to any muscle, that muscle in consequence will be deprived of its sensibility. This fact is strikingly exhibited in the experiments made by Mr. Dupuystren, at Paris, upon horses, dogs, &c. Various reasons may be assigned, and numerous conjectures made on a consideration of the facts. There is one circumstance, however, which is calculated to throw much light on the subject: when the body is deprived of a limb, it will still feel the complete organization, even to the fingers and toes; and if the nerves be cut off, which communicate to a limb, that limb will become dead to all intents and purposes, even though it still continue attached to the body.

Hence it would appear that the constitution of the animate body, consisted abundantly in the nervous capacity: that in this capacity consisted the rudimental projection, of the organization, dimensions, form and powers of the body. And it would appear from numerous facts to involve the mind itself in its provisions, even thought, reflection, reason, sympathy, and conception, would appear like electrical phenomena. It is well known that there is a most powerful sympathy between the mental and organic powers of the body. The nerves are the instruments of all the grades of sensibility, of sickness, of health, of pleasure, and of pain. They are the instruments by which the passions produce their varied effects on the muscles: Fear, dread, and terror, impart a tremor to the nerves, and produce that ghastly spectacle which we behold in cases of affright and danger: this produces a weakness and debility which has a tendency to bring on the very disorder which we dread, by depriving the nerves of their tone, and reducing them to a state of debility, similar to that which would be a natural consequence of the disorder: while on the other hand hope, confidence, and a cheerful mind have a direct and powerful tendency to strengthen, and invigorate the nerves, by improving their tone, and preserving their harmony; and this frequently does more towards checking and subduing a disorder, than the most powerful medicines.

The nervous capacity is not uniformly the same in different subjects, for were this the case the propulsion of bodies would also be uniform, and there would not exist that infinite variety which we observe in personal appearance. It is not precisely the same in any two subjects: hence it is so rare to meet with two persons nearly resembling each other. This variety is ordained by the all-wise Creator for the valuable purpose of personal discrimination. It is even subject to variations, and fluctuations in the same person, and we are not precisely the same beings two days, or even two hours together; but are perpetually suffering the inroads of change, and momently conforming to that round of variety, to which we are destined through the different stages of infancy, youth, manhood, and old age. Sometimes the deviations from the ordinary rectitude of nature are so great, and peculiar, as to produce unprecedented effects, and baffle the wisdom of philosophy and skill of physic. And it is inferable from a consideration of the infinite variations to which the nervous excitability is subject, that disease, disorder, and excitement will be infinitely various also, and cannot be reduced to an uniform, and comprehensive vocabulary. And no more can the administration of physic be reduced to a regular scale of uniform, and comprehensive prescription:

their extremities fixed to some firm bodies; since strings, otherwise constituted and disposed, have no elasticity. But it is evident, all nerves are soft at their origin, as well as void of tension: and some soft in every part, as the olfactory nerve, and the soft portion of the auditory

but must depend much on the experience, judgment and sagacity of the practising physician. It must, however, be allowed, that the physical department has been much enriched, by the labours of eminent men, and the aid of auxiliary science; and that many disorders are now well defined which were formerly considered as preternatural: and many are now found to be curable which were formerly adjudged incurable. Human society has derived the most beneficial effects from the improvements in physic, more than from its mere administration, those improvements have had a direct tendency to pull down the monster superstition, and to banish from the world a host of imaginary witches, and devils, which tormented it for ages, with their witchcrafts and incantations. Nothing was more common than to conclude when a person was afflicted with some extraordinary malady, that the patient was bewitched; and nothing was thought of as a remedy, but some incantation or charm, which filled the world with incanters, impostors, and fortune tellers. These are some of many benefits which result from the institution and improvements of physic as a science: and a good, honest, judicious, and experienced physician, one who does not delight more in experiment than in utility, like an honest lawyer, who does not delight more in fees, than in justice,—is a valuable acquisition to a community.

In the exercise of the nervous powers two very distinct capacities present themselves to our observation, the one is, that whereby the nervous effluvia is generated in the system, and which appears to be immediately employed to originate mental sensibility, and imagination. This diffuses itself from the centre to the circumference. The other is that, whereby impressions are made by outward objects, on the organs, and which appears to be the source of organic sensibility, and perception. This transfuses itself from the circumference to the centre. The former may be considered as an active, the latter as a passive capacity. In the active nervous capacity consists the degrees of animation and energy, which excite and propel to action; and which are employed to originate thought, and design. In the passive capacity consists the appetites and passions. These are invested in the external organs, which are most conveniently situated for their respective enjoyment; and which are strongly excited thereto by their peculiar irratibility. It would appear indeed as if it was the original design of the Creator, that a perfect equilibrium should exist between the mental and organic powers, and perhaps in that perfect equilibrium alone, could consist the most perfect degrees of health and enjoyment. But what strange and fatal aberrations do we witness in the world! It may indeed be asked, who lives and dies free? who is not a slave to his appetites and passions on the one hand, or a victim to a frenzied imagination on the other?

It would appear that the nerves are solid rods, which are endued with the especial capacity, to be conductors of the animal electricity. This is what we comprehend under the idea of sensibility, which is of two kinds, mental, and organic. And to preserve the system in complete harmony, their powers should be equilibriously exerted. But their harmony may be interrupted and broken by an undue preponderance. In cases of insanity in hysterics, and hypochondria, there appears evidently a derangement of the nervous system, and this appears to be of the mental kind. And convulsive, spasmodic, and paralytic affections, would appear

nerve. Yea, they all grow soft in the viscera, the muscles, and the censories, before they exert their functions. Besides, some nerves are so situate, that they cannot vibrate, as those of the heart, which are fastened to the great vessels and the pericardium. Further, the influence of an irritated nerve is never propagated upwards; whereas an elastic chord communicates tremors to both ends from the point of percursion. Hence it is plain, the nerves do not act by their spring, but by the motion of their proper fluid. The extreme smallness of these canals, which no microscope can reach, is no valid objection to this: neither our inability to discern that fluid. This only proves the imperfection of our senses.

"But what is this fluid? Who can tell?" We may very probably conjecture, it consists of some subtle fire or ether, diffused through the whole system of nature, and acting by laws unknown to us.

51. Of the other fluids, some serve to prepare the chyle; some to thin the blood and preserve it from putrefaction. Others only remain till they can be thrown out of the body, as being useless and superfluous. All of these, but the chyle, arise from the blood, being secreted from it by proper glands. But as to the manner of secretion, after all the most accurate and laborious inquiries, it still remains absolutely uncertain; and every one abounds in his own sense. Some believe it depends on the suitableness of the fluid secerned, to the shape of the secerning pores.* Some lay the stress rather on the various size and diameters of those pores; others on this, that the

to originate in a debility of the organic nervous powers. In short, it would seem as if the nerves were instituted the proper and sole directors of order in the system: that as long as they retain their native constitutional energy, they are competent to repel successfully, any attack on the vital powers: that a growing debility of the nervous powers, is a growing predisposition to some violent attack, on the vital organs: and that all sense of pain and sickness is a nervous struggle for the maintenance of their constitutional prerogatives for their native authority and precedence in the body physical, if I may be allowed the expression. And that finally death takes place, when the nerves have lost their powers of action, and reaction; and can no longer propel, or stimulate the muscles, and vascular organs.

* Chylification, is unquestionably performed by a chemical elaboration, and solution of the substances taken as food. In which operation the various humours secreted in the viceral glands, act an important part. The operation has been thought by some to be carried on by certain laws of affinity, whereby suitable particles were selected from the elaborated mass, presented to the orifices of the secretory glands, in the intestinal canal. But this position will appear unfounded, from a consideration of the use, and operation of medicine; the effect of certain colours taken into the stomach, and the more violent operation of poison; which penetrates the entire system, lawless, and destructive to life. Hence it becomes necessary to be careful, what articles we take as food: and it is prudent, and wise to suit the quality of food, to the prevailing state of the body; to maintain its equilibrium, and preserve the health.

constituent particles, suppose of the bile, from their peculiar proportion, texture and figure, may be more easily united to each other, than to the particles of lymph, or any other fluid.

52. The chief of all the fluids in our body, and the fountain of life, is the BLOOD. It consists of a watery serum, fibrous particles, and red globules, which last are scarce a twelfth part of it. It is generated thus. The meat and drink being digested into chyle, pass from the intestines, through the lacteal veins and the thoracic duct, into the left subclavian vein, and thence into the *vena cava*, where it mixes with the blood, and then circulates with it, till it is wholly assimulated.

Blood, fresh drawn, appears to the naked eye, uniform und homogenous. But when cold, it separates into two parts: the one red and fibrous, which clots together; the other thin and transparent, called SERUM, in which the former swims. The serum is in bulk three-fourths of the blood; in weight fifteen-seventeenths.

A red globule is computed to be 25000 times smaller than the smallest grain of sand: but whence arises the heat, and colour of the blood; this deserves a particular inquiry.*

* By new improvements and discoveries in chemical philosophy, the origin of animal heat is well ascertained, and accounted for on entire new principles. It appears from a concurrence of well known facts, and from every possible investigation of the case, that animal heat is generated in the lungs, in consequence of the decomposition of oxygen and inflammable air in those organs. After the blood has performed its wonted functions in its course through the arteries, and disburdened itself of its repletive matter, it becomes very much exhausted, and assumes a very different character. In this exhausted state it would be impossible to furnish further supplies of nourishment to the body. Could it immediately enter into the arteries, and run its course again through those organs, thus impoverished, instead of life and nourishment, it would carry death and destruction to the living system. Thus expended the blood requires to be regenerated and renewed from its impurities and repleted with vital nourishment, before it is fit to enter again into the arteries. For this purpose, and in its exhausted and impure state, the veins whose office it is, take it up in all directions, where it is finally ejected by the ramifications of the arteries, to elaborate and prepare it for its renovation in the lungs. In its passage through the veins it is supplied with the particular humours which are necessary to produce in it, a state of fermentation: for the purpose of evolving the inflammable matter, which it has acquired in circulation. These are hydrogen, and carbon: and which occasion the dark purple colour observable in veinous blood. In this situation the blood is propelled to the lungs, where its impurities are presented in the state of inflammable air, to the oxygen furnished by inspiration in those organs. Here a decomposition of the matters in contact takes place, and caloric which is the basis, or matter of heat, is set at liberty. Thus is animal heat generated, and supplied to the blood to be distributed in its course through the system.

The heat thus generated may be discriminately considered as vital heat, and probably is of a specific nature, and different from that evolved by friction, combustion, and other chemical decompositions. Should this be the case, how much

Borelli took some of the red part, and washing it frequently in water, found it separable into a viscous slippery substance, consisting of colourless fibres, which rose and gathered into a scum on the top of the water, and a deep red powder, which precipitated plentifully to the bottom. Hence it appears that the redness of the blood springs from red tinging particles, as in the case of dying.

However this red colour, though generally found in the blood of land animals, is not absolutely necessary, there being some species, whose blood is white or limped. Nay, Dr. Drake let out of the median vein of a man, a pure, white blood, like milk, which, when cold, did not separate into two parts, as the red usually does. Nor yet did it yield any skim or cream, neither turn sour as milk uses to do. Dr. Beal gives an instance of the same kind; and Dr. Lower relates one as strange. A person bled at the nose, till at length the broth he drank flowed out very little altered.

It is amazing to see how careful Providence has been to prevent the blood's running into concretions, which might destroy life, by the very dispositions of the vessels it is to run through. These are so contrived, as to cause the globules to come together with a brisk collision. The arteries which convey the blood from the heart to the extremities, continually lessen, as they recede from their source; in consequence of which, the globules of blood must rush with force against one another, as they are driven on impetuously. And the veins which bring it back from the extremities to the heart, enlarging all the way as they go on, while the streams of several continually run into one, each of these ingresses causes new commotions, capable, though not of dissolving that natural connexion of the red and serious particles, yet of preventing any preternatural concretions or coagulations.

53. These are the parts of which this wonderful machine is composed, and which are derived from a few simple primary, elementary substances, commixed and wrought together with such wonderful precision, and in such diverse ratios, as to produce all that variety we

is lost to science, and to humanity for the want of means to ascertain so important a fact.

It has been noticed, that the blood derives its dark colour from its union with hydrogen, and carbon, with which it comes loaded to the luugs, but no sooner have the inflammable gasses been decomposed by their contact with the oxygen in the lungs, than the blood assumes that bright red colour, which is observable in arterial blood. The blood is subject to a great variety of shade, in proportion as it is acted upon by oxygen, and hydrogen. It has been observed in some instances to be of a very light red; in others bordering upon the whitish yellow colour of chyle; and in others quite white. Hence it may be inferred that the colour of the blood is owing to a particular modification, which it undergoes, in proportion as it is acted upon by the different gasses, with which it is concerned.

observe in nature. And what is truly admirable, the same particles which enter into the composition serve but a transient purpose, while they perform a certain routine of service in the system, which leaving completed, they become exhausted and redundant, and are finally evacuated as dead, and unqualified for farther utility, to make room for a fresh supply, which bring new life and sustenance, and which are soon to experience the same destiny with their predecessors. Thus all matter moves in a constant reverberation. And it may be truly said, that the matter which clothes the present body, clothed the bodies of our ancestors some thousand years ago, and will continue its successive alterations as long as the world shall endure.

All matter is capable of entering alternately, into the concrete, and ariform state. The hardest substance in nature, which is the diamond, is capable of being converted into air. There is not a solitary substance which enters into the composition of the globe, but has its relative, component particles abstractly afloat in air ; and which is not derived from air. But in general those different states of matter are discriminated by the terms, earth and air. And much of the latter is found by experiment to commix with the former; and serves the important purpose, to give elasticity to bodies.

That much air is wrought into the whole animal frame, appears by the following experiments. The blood of a sheep, fresh drawn, was in a wide-mouthed glass put into a receiver, and the air drawn out; after awhile, the subtile parts of the blood forced their way through the clammy ones, and seemed to boil in large clusters, some as big as nutmegs. And sometimes the expansion was so vehement, that it boiled over the glass. Some milk being put into a vessel four or five inches high, when the air was drawn out, it boiled so impetuously, as to throw up several parts out of the glass that contained it.

And to shew, that not only the blood, but the other parts of animals include air, the liver of an eel was put into a receiver, and even this apparently swelled every way, as soon as the air was withdrawn.

The air, as a fixed element in the composition of solid and fluid bodies, had been generally overlooked by philosophers, and even by the chemists, until Mr. Boyle, Sir Isaac Newton, and more especially Dr. Hales, by many experiments demonstrated, that a great part of the substance of most bodies, in several to half their weight, is a permanent air, which being freed (either *slowly*, by the air-pump, putrefaction, fermentation, distillation, &c. or *suddenly* by explosions, fulminations, ebullitions, mixtures, &c.) from the other solid particles, assumes its elasticity, and fills an immense space, in comparison of the body from whence it came. Dr. Hales found a cubic inch of blood in distillation, afforded above 30 times its bulk of elastic air ; whose par-

ticles are in effect the wedges of nature which pin and cement together the other elements, and particles of bodies for their growth of accretion; and under other circumstances, regaining their elasticity, serve to break again those parts for the dissolution of the compound, whose matter may be, by the same instrument, again differently assembled and combined for the forming of other bodies.

54. It remains to add some reflections on the wisdom of God, displayed, in the structure of the human body And how eminently is this displayed, first, in the situation of its several parts and members! They are situated most conveniently for use, for ornament, and for mutual assistance. 1. For use. The principal senses are placed in the head, as sentinels in a watch-tower. How could the eyes have been more commodiously fixt, for the guidance of the whole body? The ears likewise, made for the reception of sounds, which naturally move upward, are rightly placed in the uppermost part of the body; and so are the nostrils, as all odours ascend. Again: how could the hands have been more conveniently placed, for all sorts of exercises? Or the heart, to dispense life and heat to the whole body? Or the sinks of the body, that in the most remote parts of it? 2. For ornament. Not to descend to particulars, what could be better contrived, than that those members which are pairs should be of equal length, and just answer one another on each side? 3. For mutual assistance. So the eye stands most conveniently to guide the hand, and the hand to defend the eye. The same may be said of the other parts: they are all so placed, as to direct or help each other. This will clearly appear, if you suppose the position of any of them to be changed. Had our arms been bent backward, what direction could our eyes have afforded us in working? Or how could we even have fed ourselves? Nay, had one arm bent backward, and the other forward, half the use of them had been lost, for one could not have assisted the other in any action.

How is His wisdom displayed, secondly, in the ample provision made for the security of the principal parts! These are, 1. The heart, the fountain of life. This lies in the centre of the trunk of the body, covered with its own membrane; the pericardium, lodged within the soft bed of the lungs, encompassed round with a double fence, both of thick muscles and skins, and of firm ribs and bones; besides the arms, conveniently placed to ward off any violence. 2. The brain, the principle of all sense and motion, is surrounded with so strong a defence, that it must be a mighty force indeed, which is able to injure it. The skull is so hard, thick and tough, that it is almost as firm as a helmet of iron. This is covered with skin and hair, which both keep it warm, and soften the violence of a stroke. Yet more, a

thick and tough membrane hangs loose about it, which often saves it, even when the skull is broke. And lastly, a fine membrane closely adheres, to keep it from quashing and shaking.

How is it displayed, thirdly, in the abundant provision that is made against evil accidents and inconveniencies! To this end, 1. The members which are of eminent use are in pairs. We have two eyes, ears, nostrils, hands; two feet, two breasts, two kidneys; that if one should be rendered useless, the other might serve us tolerably well: whereas had a man but one hand or eye, if that were gone, all were gone. 2. All the vessels have many ramifications, which send forth twigs to the neighbouring vessels: so that if one branch be cut or obstructed, its want may be supplied by the twigs from the neighbouring vessels. 3. Many ways are provided to evacuate, whatever might be hurtful to us. If any thing oppress the head, it can free itself by sneezing; if the lungs, they can cast it off by coughing; if any thing burden the stomach, it can contract itself, and throw it up by vomit. Beside these evacuations, there are siege, urine, sweat, and hæmorrhages of various kinds. 4. Whereas sleep is necessary for us in many respects, nature has provided, that though we lie long on one side, we should feel no uneasiness while we sleep; no nor when we awake. One would think, the whole weight of the body pressing the muscles on which we lie, would be very burdensome. And we find by experience, so it is, when we lie long awake in the night. Probably this provision is made, by an inflation of the muscles, making them soft, and yet renitent, like pillows. That they are inflated during sleep, appears to the very eye, in the faces of children; and from the common experiment that if we sleep in our clothes, we must loosen our garters and other ligatures, otherwise we find uneasiness in those parts. 5. Because sleep is inconsistent with the sense of pain, therefore during rest, those nerves that convey the motions to the brain, which excite the sense of pain, are obstructed. "This I myself," says Mr. Ray, "have often experienced, since I have had sores on my legs. Waking suddenly, I find myself at perfect ease for awhile. Then the pain by degrees returns."

It is displayed, fourthly, in the multitude of intentions God hath in the formation of the several parts, and the multitude of qualifications they require to fit them for their several uses. Galen observes, "that there are in the human body, above six hundred muscles. And there are at least ten several intentions in each, and as many qualifications needful: so that about the muscles alone, no less than 6000 ends are to be attended to. The bones are reckoned to be 284. The distinct intentions in each of these are above forty: in all about a hundred thousand. And thus it is, in proportion, with all the other parts: the skin, ligaments, veins, arteries, nerves, glands, humours;

but more especially with the members of the body, which as to the multitude of intentions and qualifications, far exceed the similar parts. And should one of these qualifications fail, great inconvenience would ensue."

It is displayed, fifthly, in the stature of man, so admirably well adapted to the circumstances of his existence. Had man been only a foot or two high, he had been quite disproportioned to every thing round about him. Had he been much larger, he could not well have been supplied with food: all the edible animals would not have sufficed. And had they too been proportioned larger, the surface of the earth would not have sufficed to feed them.

It is however a common opinion, and has been so ever since old Homer's time, that the people in the early ages of the world, were much larger than us. And it is true we read of some men of a surprising stature. But they were even then esteemed giants. The ordinary stature of men, is probably just the same now, as it was at the beginning. This may be gathered from the monuments still remaining, particularly the pyramids of Egypt. The cavities for bodies now visible herein, are little larger than our ordinary coffins: likewise from several embalmed bodies taken out of them, it appears, that men are of the same stature now, that they were when those pyramids were built, which is at least three thousand years ago. Eighteen hundred years ago, the emperor Augustus was five feet seven inches high: queen Elizabeth was taller by two inches, being five feet nine.

But what a paradox is it that all men are taller in the morning than in the evening? In a young man, the difference is near an inch; try the experiment as often as you please. Does not the difference proceed from hence, that as long as the trunk of the body is in an erect posture, there is a constant pressure on the large cartilages connecting the vertebræ of the spine? So long they gradually contract, and consequently a man grows shorter. But they again gradually expand themselves, while we are in a reclining posture.

As to the art of embalming, it appears from a mummy, not long since dug up in France, that this was more completely understood in the western world some ages since, than ever it was in Egypt. This mummy which was dug up at Auvergne, was an amazing instance of their skill. As some peasants were digging in a field near Rion, within about twenty-six paces of the highway, between that and the river Artier, they discovered a tomb, that was about a foot and a half beneath the surface. It was composed only of two stones; one of which formed the body of a sepulchre, and the other the cover.

This tomb was of freestone; seven feet and a half long, three feet and a half broad, and about three feet high. It was of rude workmanship; the cover had been polished, but was without figure or inscrip-

tion: within this tomb was placed a leaden coffin, four feet seven inches long, fourteen inches broad, and fifteen high. It was oblong, like a box, equally broad at both ends, and covered with a lid that fitted on like a snuff-box, without a hinge. Within this coffin was a mummy, in the most perfect preservation. The internal sides of the coffin were filled with an aromatic substance, mingled with clay. Round the mummy was wrapped a coarse cloth; under this were two shirts, or shrouds, of the most exquisite texture; beneath these a bandage, which covered all parts of the body, like an infant in swaddling clothes; under this general bandage there was another, which went particularly round the extremities, the hands and legs; the head was covered with two caps: the feet and hands were without any particular bandages; and the whole body was covered with an aromatic substance, an inch thick. When these were removed, and the body exposed naked to view, nothing could be more astonishing than the exact resemblance it bore to a body that had been dead a day or two before. It appeared well proportioned, except the head was rather large, and the feet small. The skin had all the pliancy, and colour of a body lately dead; the visage, however, was of a brownish hue. The belly yielded to the touch; all the joints were flexible, except those of the legs and feet; the fingers stretched forth of themselves when bent inwards. The nails still continued perfect; and all the marks of the joints, both in the fingers, the palms of the hands, and the soles of the feet, remained perfectly visible. The bones of the arms and legs were soft and pliant; those of the skull preserved their rigidity; the hair which only covered the back of the head, was of a chesnut colour, and about two inches long. The pericranium at top was separated from the skull, by an incision, in order to the introducing aromatics in the place of the brain, where they were found mixed with clay. The teeth, the tongue, and the ears, were all preserved in perfect form. The intestines were not taken out of the body, but remained pliant and entire, as in a fresh subject; and the breast was made to rise and fall like a pair of bellows. The embalming preparation had a very strong and pungent smell, which the body preserved for more than a month after it was exposed to the air. If one touched either the mummy, or any other part of the preparation, the hand smelt of it for several hours after. This mummy, having been exposed for some months, began to suffer some mutilations. A part of the skin of the forehead was cut off; all its teeth were drawn out, and some attempts were made to pull away the tongue. It was therefore put into a glass case, and transmitted to the king's cabinet, at Paris.

There are many reasons to believe this to be the body of a person of the highest distinction: however no marks remain to assure us

either of the quality of the person, or the time of his decease. There are only to be seen some irregular figures on the coffin ; one of which represents a kind of star.

There were also some singular characters upon the bandages, which were totally defaced by those who had tore them. It should seem that it had remained for several ages in this state, since the first years immediately succeeding the interment, are usually those in which the body is most liable to decay.

On this remarkable subject, I beg leave to add an extract from a late author.

"I always apprehended that human bodies after death, if interred, or exposed to the air, without any preparation to defend them from the attacks of it, would of necessity corrupt, become offensive, and putrify. The art of embalming is very ancient, and was invented to preserve them from this inevitable consequence of death ; but that they may remain unputrified for centuries, without any sort of artificial aid, I have seen so incontestibly proved since my arrival at Bremen, that I imagine not the shadow of doubt can remain about it. Under the cathedral church is a vaulted apartment, supported on pillars ; it is near sixty paces long, and half as many broad. The light and air are constantly admitted into it by three windows, though it is several feet beneath the level of the ground. Here are five large oak coffers, rather than coffins, each containing a corpse. The most curious and perfect, is that of a woman. Tradition says, she was an English countess, who dying here at Bremen, ordered her body to be placed in this vault uninterred, in the apprehension that her relations would cause it to be brought over to her native country. They say it has lain here two hundred and fifty years. Though the muscular skin is totally dried in every part, yet so little are the features of the face sunk or changed that nothing is more certain than that she was young, and even beautiful. It is a small countenance, round in its contour ; the cartilage of the nose and the nostrils have undergone no alteration : her teeth are all firm in the sockets, but the lips are drawn away from over them. The cheeks are shrunk in, but yet less than I ever remember to have seen in embalmed bodies. The hair of her head is at this time more than eighteen inches long, very thick, and so fast, that I heaved the corpse out of the coffer by it; the colour is a light brown, and I cut off a small lock, which is as fresh and glossy as that of a living person. That this lady was of high rank, seems evident from the extreme fineness of the linen which covers her body. The landlord of the inn, who was with me, said, he remembered it for forty years past ; during which time there is not the least perceptible alteration in it. In another coffer is the body of a workman who is said to have tumbled off the church, and was killed

by the fall. His features evince this most forcibly. Extreme agony is marked in them: his mouth is wide open, and his eyelids the same; the eyes are dried up. His breast is unnaturally distended, and his whole frame betrays a violent death. A little child who died in the small-pox is still more remarkable. The marks of the pustules, which have broken the skin on his hands and head, are very discernible; though one should suppose that a body which died of such a distemper, must contain in a high degree the seeds of putrefaction.—The two other corpses are not less extraordinary. There are in this vault likewise turkeys, hawks, weasels, and other animals, which have been hung up here, some, time immemorial, some very lately, and are in the most complete preservation: the skin, bills, and feathers, are all unaltered. The magistrates do not permit that any fresh bodies be brought here. The cause of these phenomenæ are doubtless the dryness of the place where they are laid. It is in vain to seek for any other."

A repository of nearly the same kind, a late writer informs us is at a monastery, near Palermo, in Sicily. It is a long, subterranean gallery, having niches on every side, between six and seven feet high. In each of these is a human body standing erect, in its usual apparel. The face and hands are uncovered, and preserve their shape, and natural colour, only a little browner. They are fastened to the wall by the back. Some of them are believed to have been there two or three hundred years. Suppose they could remain there for ever, what would it profit their former inhabitants?

Another traveller gives a fuller account of them.

"This morning we went to see a celebrated convent of capuchins, about a mile without the city of Palermo; it contains nothing very remarkable, but the burial-place which is indeed a great curiosity. This is a vast subterraneous apartment, divided into large commodious galleries, the walls on each side of which are hollowed into a variety of niches, as if intended for a great collection of statues: these niches, instead of statues, are all filled with dead bodies, set upright upon their legs, and fixed by the back to the inside of a niche. Their number is about three hundred: they are all dressed in the clothes they usually wore, and form a most respectable and venerable assembly. The skin and muscles, by a certain preparation, become as dry and hard as a piece of stock-fish: and although many of them have been here upwards of two hundred and fifty years, yet none are reduced to skeletons; though the muscles in some are more shrunk than in others; probably because these persons had been more extenuated at the time of their death.

"Here the people of Palermo pay daily visits to their deceased friends, and recal with pleasure and regret the scenes of their past

life; here they familiarize themselves with their future state, and choose the company they would wish to keep in the other world. It is a common thing to make choice of their niche, and to try if their body fits it, that no alterations may be necessary after they are dead; and sometimes by way of voluntary penance, they stand for hours in these niches.

"The bodies of the princes and first nobility are lodged in handsome chests or trunks, some of them richly adorned: these are not in the shape of coffins, but all of one width, and about a foot and a half or two feet deep. The keys are kept by the nearest relations of the family, who sometimes come and drop a tear over their departed friends.

"These visits must prove admirable lessons of humility; and they are not such objects of horror as one would imagine; they are said, even for ages after death, to retain a strong likeness of what they were when alive: so that, as soon as you have conquered the first feelings excited by these venerable figures, you only consider this as a vast gallery of original portraits, drawn after the life, by the justest and most unprejudiced hand. It must be owned, that the colours are rather faded; and the pencil does not appear to have been the most flattering in the world: but no matter; it is the pencil of truth, and not of a mercenary, who only wants to please.

"It might also be made of very considerable use to society; these dumb orators could give the most pathetic lectures upon pride and vanity. Whenever a fellow began to strut, or to effect the haughty, supercilious air, he should be sent to converse with his friends in the gallery; and if their arguments did not bring him to a proper way of thinking, I would give him up as incorrigible."

I cannot better conclude this chapter than by an extract from the late pious and ingenious Mr. Hervey, which may serve for a recapitulation of what has been said, as well as an improvement of it.

"Let us begin with the less adorned, but more solid parts, those which support, and which contain the rest. First, you have a system of bones, cast in a variety of moulds, in a variety of sizes; all strong, that they may bear up the machine, yet light, that they may not weigh us down: bored with an inward cavity to contain the moistening marrow, and perforated with fine ducts to admit the nourishing vessels. Insensible themselves, they are covered with a membrane, exquisitely sensible, which warns them of, and secures them from the annoyance of any hurtful friction; and also preserves the muscles from being fretted in their action, by the hard and rough substance of the bone. They are larger at the extremities, that they may be joined more firmly, and not so easily dislocated. The manner of their articulation is truly admirable, and remarkably various; yet

never varied, without demonstrating some wise design, and answering some valuable end. Frequently when two are united, the one is nicely rounded and capped with a smooth substance; the other is scooped into a hollow of the same dimensions to receive it. And both are lubricated with an unctuous fluid, to facilitate the rotation.

"The FEET compose the firmest pedestal, infinitely beyond all that statuary can accomplish, capable of altering its form, and extending its size, as different circumstances require. They likewise contain a set of the nicest springs, which help to place the body in a variety of attitudes, and qualify it for the multiplicity of motions. The undermost part of the heel, and the extremity of the sole, are shod with a tough insensible substance; a kind of natural sandal, which never wears out, never wants repair: and which prevents an undue compression of the vessels by the weight of the body. The legs and thighs are like stately columns, so articulated that they are commodious for walking, and yet do not obstruct the easy posture of sitting. The legs swell out towards the top with a genteel projection, and are neatly wrought off toward the bottom: a variation which lessens their bulk, while it increases their beauty.

"The RIBS, turned into a regular arch, are gently moveable, for the act of respiration. They form a safe lodgment for the lungs and heart, some of the most important organs of life. The back-bone is designed, not only to strengthen the body, and sustain its most capacious store rooms, but also to bring down the continuation of the brain, usually termed the spinal marrow. It both conveys and guards this *silver cord*, as Solomon terms it, and by commodious outlets transmits it to all parts. Had it been only strait and hollow, it might have served these purposes. But then the loins must have been inflexible; to avoid which, it consists of very short bones, knit together by cartilages. This peculiarity of structure gives it the pliancy of an osier, with the firmness of an oak. By this means it is capable of various inflections, without bruising the soft marrow, or diminishing that strength which is necessary to support all the upper stories. Such a formation in any other of the solids, must have occasioned great inconvenience. Here it is unspeakably useful, a masterpiece of creating skill.

"The ARMS are exactly proportioned to each other, to preserve the equilibrium of the structure. These being the guards that defend, and the ministers that serve the whole body, are fitted for the most diversified and extensive operations: firm with bone, yet not weighty with flesh, and capable of performing all useful motions. They bend inwards and turn outwards; they move upward or downward; they wheel about in whatever direction we please. To these are added the HANDS, terminated by the fingers, not of the same length, nor of

equal bigness, but in both respects different, which gives the more beauty, and far greater usefulness. Were they all flesh, they would be weak: were they one entire bone, they would be utterly inflexible; but consisting of various little bones and muscles, what shape can they not assume? Being placed at the end of the arm the sphere of their action is exceedingly enlarged. Their extremities are an assemblage of fine tendinous fibres, acutely sensible: which notwithstanding are destined to almost incessant employ, and frequently among rugged objects. For this reason they are overlaid with nails, which preserve them from any painful impression.

"In the hands we have a case of the finest instruments. To these we owe those beautiful statues, this melodious trumpet. By the strength of the hand the tallest firs fall, and the largest oaks descend from the mountains. Fashioned by the hand they are a floating warehouse, and carry the productions of art and nature from Britain to Japan.

"The hand is the original and universal sceptre, which not only represents, but ascertains our dominion over all the elements, and over every creature. Though we have not the strength of the horse, the swiftness of the greyhound, or the quick scent of the spaniel, yet directed by the understanding, and enabled by the hand, we can as it were make them all our own. These short hands have found a way to penetrate the bowels of the earth, to touch the bottom of the sea. These feeble hands can manage the wings of the wind, arm themselves with the violence of fire, and press into their service the forcible impetuosity of water. How greatly then are we indebted to our wise Creator, for this distinguishing, this invaluable member!

"Above all is the HEAD, for the residence of the brain; ample to receive, and firm to defend it. It has a communication with all, even the remotest parts: has outlets, for despatching couriers to all quarters, and avenues for receiving speedy intelligence, on all needful occasions. It has lodgments wherein to post centinels, for various offices: to expedite whose operations the whole turns on a curious pivot, nicely contrived to afford the largest and freest circumvolutions.

"This is screened from heat, defended from cold, and at the same time beautified by the hair: a decoration so delicate, as no art can supply; so perfectly light, as no way to incumber the wearer.

"While other animals are prone in their aspect, the attitude of man is erect, which is by far the most graceful, and bespeaks superiority. It is by far the most commodious, for prosecution of all our extensive designs. It is likewise safest, less exposed to dangers, and better contrived to repel or avoid them. Does it not also remind us of our noble original, and our sublime end? Our original, which was

the breath of the Almighty: our end, which was the enjoyment of him in glory?

"Thus much for the *rafters* and *beams* of the house. Let us now survey the lodgings within. Here are LIGAMENTS, a tough and strong arrangement of fibres, to unite the several parts, and render what would be otherwise an unwieldly jumble, a well compacted and self-manageable system: MEMBRANES, thin and flexible, tunicles to enwrap the fleshy parts, to connect some, and form a separation between others: ARTERIES, the rivers of our little world, that striking out as they go, into numberless small canals, visit every street, yea, every apartment in the vital city. These being wide at first, and growing narrower and narrower, check the rapidity of the blood. This thrown from the heart, dilates the arteries, and their own elastic force contracts them: by which means they vibrate against the finger, and much assist both in the discovery and cure of diseases. The larger arteries, wherever the blood is forced to bend, are situate on the bending side: lest being stretched to an improper length, the circulation should be retarded. They are not, like several of the veins, near the surface, but placed at a proper depth. And hereby they are more secure from external injuries. In those parts which are most liable to pressure, an admirable expedient takes place. The arteries inosculate with each other: breaking into a new tract, they fetch a little circuit, and afterwards return into the main road. So that if any thing block up or straiten the direct passage, the current, by diverting into this new channel, eludes the impediment, flows on, and soon regains its wonted course.

"The VEINS receive the blood from the arteries, and reconvey it to the heart. The pressure of the blood is not near so forcible in these as in the arteries. Therefore their texture is considerably slighter. Such an exact economist is nature, amidst all her liberality! In many of these canals, the current, though widening continually, is obliged to push its way against the perpendicular: hereby it is exposed to the danger of falling back and overloading the vessels. To prevent this, VALVES are interposed at proper distances, which are no hindrance to the regular passage, but prevent the reflux, and facilitate the passage of the blood to the grand receptacle. But these valves are only where the blood is constrained to climb: where the ascent ceases, they cease also.

"Here are GLANDS to filtrate the passing fluids: each of which is an assemblage of vessels, complicated with seeming confusion, but with perfect regularity. Each forms a secretion far more curious than the most admired operations of chemistry: MUSCLES, composed of the finest fibres, yet endued with incredible strength, fashioned after a variety of patterns, but all in the highest taste for elegance

and conveniency. These are the instruments of motion, and at the command of the will, execute their functions quick as lightning: NERVES, surprisingly minute, which set the muscles at work, diffuse the power of sensation through the body, and upon any impression from without, give all needful intelligence to the soul: VESICLES, destined with an unctuous matter, in some places compose a soft cushion; as in the calf of the leg, whose large muscles, mixt with fat, are of singular service to those important bones. This flanks and fortifies them, like a strong bastion; supports and cherishes them, like a soft pillow. In other places they fill up the vacuities, and smooth the inequalities of the flesh. Inwardly, they supply the machine for motion: outwardly, they render it smooth and graceful.

"The SKIN, like a curious surtout, covers the whole, formed of the most delicate net-work, whose meshes are minute, and whose threads are multiplied, even to a prodigy: the meshes are so minute, that nothing passes them, which is discernible by the eye; though they discharge, every moment myriads and myriads of superfluous encumbrances. The threads are so multiplied, that neither the point of the smallest needle, nor the infinitely finer lance of a gnat, can pierce any part, without drawing blood, and causing an uneasy sensation. Consequently, without wounding, by so small a puncture, both a nerve and a vein!

"But a course of incessant action must exhaust the solids and waste the fluids, and unless both are properly recruited, in a short time destroy the machine. For this reason it is furnished with the organs, and endued with the powers of nutrition: TEETH, the foremost, thin and sharp, to bite asunder the food; the hindermost, broad and strong, indented with small cavities, the better to grind in pieces what is transmitted to them. But in children, the formation of teeth is postponed till they have occasion for them.

"Were the teeth, like other bones, covered with the periosteum, chewing would give much pain. Were they quite naked, they would soon decay and perish. To guard against both, they are overlaid with a neat ENAMEL, harder than the bone itself, which gives no pain in chewing, and yet secures them from various injuries.

"The LIPS prevent the food from slipping out of the mouth, and assisted by the tongue, return it to the grinders. While they do this in concert with the checks, they squeeze a thin liquor from the adjacent glands. This moistens the food and prepares it for digestion. When the mouth is inactive, these are nearly closed: but when we speak or eat, their moisture being then necessary, is expressed as needs require.

"But the food could not descend merely by its own weight, through a narrow and clammy passage into the stomach. Therefore

to affect this, muscles both straight and circular are provided. The former enlarge the cavity, and give an easy admittance. The latter, closing behind the descending aliment, press it downward. But before the food enters the gullet, it must of necessity pass over the orifice of the windpipe: whence it is in danger of falling upon the lungs, which might occasion instant death. To obviate this, a moveable lid is placed, which when the smallest particle advances, is pulled down and shut close, but as soon as it is swallowed, is let loose and stands open. Thus the important pass is always made sure against any noxious approaches; yet always left free for the air, and open for respiration.

"The food descending into the stomach, is not yet ready for the bowels. Therefore that great receiver is strong to bear, and proper to detain it, till it is wrought into the smoothest pulp imaginable. From hence it is discharged by a gentle force, and passes gradually into the intestines.

"Near the entrance waits the GALL-BLADDER, ready to pour its salutary juice upon the aliment, which dissolves any thing viscid, scours the intestines, and keeps all the fine apertures clear. This bag, as the stomach fills, is pressed thereby, and then only discharges its contents. It is also furnished with a valve of a very peculiar nature, namely, of a spiral form; through which the detersive liquid cannot hastily pour, but must gently ooze. Admirable construction! which without any care of ours, gives the needful supply, and no more.

"The nutriment then pursues its way through the mazes of the intestines: which by a worm like motion protrude it and force its small particles into the lacteal vessels. These are a series of the finest strainers, ranged into countless multitudes all along the sides of the winding passage. Had this been strait or short the food could not have resigned a sufficient quantity of its nourishing particles. Therefore it is artfully convolved, and greatly extended, that whatever passes may be sifted thoroughly. As the aliment proceeds, it is more and more drained of its nutricious juices. In consequence of this, it would become hard, and pain the tender parts, but that glands are posted in proper places, to discharge a lubricated fluid. These are smaller or fewer, near the stomach, because there the aliment is moist enough: whereas in the bowels, remote from the stomach, they are either multiplied or enlarged.

"The CHYLE drawn off by the lacteals is carried through millions of ducts, too fine even for the microscope to discover. To this it is owing, that nothing enters the blood, but what is capable of passing through the finest vessels. It is then lodged in several commodious cells (the glands of the mesentry) and there mixt with a thin diluting lymph, which makes it more apt to flow. Hence it is conveyed to the

common receptacle, and mounts through a perpendicular tube into the left subclavian vein. This tube lies contiguous to the great artery, whose strong pulsation drives on the fluid, and enables it to ascend and unload its treasure, at the very door of the heart.

"But the chyle is as yet in too crude a state, to be fit for the animal functions. Therefore it is thrown into the lungs. In the spongy cells of this amazing laboratory, it mixes with the external air, and its whole substance is made more smooth and uniform. Thus improved it enters the left ventricle of the heart, a strong, active, indefatigable muscle. The large muscles of the arm or of the thigh are soon wearied: a day's labour, or a day's journey exhausts their strength. But the heart toils whole weeks, whole months, nay years, unwearied: is equally a stranger to intermission and fatigue. Impelled by this, part of the blood shoots upward to the head; part rolls through the whole body.

"But how shall a stream, divided into myriads of channels, be brought back to its source? Should any portion of it be unable to return, putrefaction, if not death, must ensue. Therefore the all-wise Creator has connected the extremities of the arteries, with the beginning of the veins: so that the same force which darts the blood through the former, helps to drive it through the latter. Thus it is reconducted to the great cistern, and there played off afresh.

"Where two opposite currents would be in danger of clashing, where the streams from the *vena cava* and *vena ascendens* coincide, a fibrous excrescence interposes, which like a projecting pier, breaks the stroke of each and throws both into their proper receptacle. Where the motion is to be speedy, the channels either forbear to wind (as in the great artery, which descends to the feet) or to lessen in their dimensions, as in every interval between all the ramifications. When the progress is to be retarded, the tubes are variously convolved, or their diameter contracted. Thus guarded, the living flood never discontinues its course, but night and day, whether we sleep or wake, still perseveres to run briskly through the arteries and return softly through the veins.

"But farther: the great Creator has made us an invaluable present of the senses, to be the inlets of innumerable pleasures, and the means of the most valuable advantages.

"The EYE, in its elevated station, commands the most enlarged prospects. Consisting only of fluids, enclosed within coats, it shews us all the graces and glories of nature. How wonderful, that an image of the hugest mountains, and the widest landscapes should enter the small pupil! that the rays of light should paint on the optic nerve, paint in an instant of time, paint in the truest colours and exact lineaments, every species of external objects!

"The eye is so tender, that the slightest touch might injure its delicate frame. It is guarded therefore with peculiar care, intrenched deep, and barricaded round with bones. As the smallest fly might incommode its polished surface, it is farther protected by two substantial curtains. In sleep, when there is no occasion for the sense, but a necessity to guard the organ, these curtains close of their own accord. At any time they fly together as quick as thought. They are lined with an extremely fine sponge, moist with its own dew. Its bristly palisades keeps out the least mote, and moderate the too strong impressions of the light.

"As in our waking hours we have almost incessant need for these little orbs, they run upon the finest castors, rolling every way with the utmost ease; which circumstance, added to the flexibility of the neck, renders our two eyes as useful as a thousand.

"The EAR consists of an outward porch and inner rooms. The porch somewhat prominent from the head, is of a cartilaginous substance, covered with tight membranes and wrought into sinuous cavities. These, like circling hills, collect the wandering undulations of the air, and transmit them with a vigorous impulse, to the finely stretched membrane of the drum. This is expanded upon a circle of bones, over a polished, reverberating cavity. It is furnished with braces that strain or relax, as the sound is faint or strong. The hammer and the anvil, the winding labyrinth, and the sounding galleries, these and other pieces of mechanism, all instrumental to hearing, are inexpressibly curious.

"Amazingly exact must be the tension of the auditory nerves, since they answer the smallest tremors of the atmosphere, and distinguish their most subtle variations. These living chords, turned by an Almighty hand, and spread through the echoing isles, receive all the impressions of sound and propagate them to the brain. These give existence to the charms of music, and the still nobler charms of discourse.

"The eye is useless amidst the gloom of night: but the ear hears through the darkest medium. The eye is on duty only in our waking hours: but the ear is always accessible.

"As there are concussions of the air, which are discernible only by the instruments of hearing, so there are odoriferous particles wafted in the air, which are perceivable only by the smell. The nostrils are wide at the bottom, that more effluvia may enter, narrow at the top, that when entered, they may act more strongly. The streams that exhale from fragrant bodies, are fine beyond imagination. Microscopes that shew thousands of animals in a drop of water, cannot bring one of these to our sight. Yet so judiciously are the olfactory nets set, that they catch the vanishing fugitives. They

imbibe all the roaming perfumes of spring, and make us banquet even on the invisible dainties of nature.

" Another capacity for pleasure our bountiful Creator has bestowed, by granting us the powers of TASTE. This is circumstanced in a manner so benign and wise, as to be a standing plea for temperance, which sets the finest edge on the taste, and adds the most poignant relish to its enjoyments.

" And these senses are not only so many sources of delight, but a joint security to our health. They are the inspectors that examine our food, and inquire into the properties of it. For the discharge of this office they are excellently qualified, and most commodiously situate. So that nothing can gain admission, till it has past their scrutiny.

" To all these, as a most necessary supplement, is added the sense of FEELING. And how happily is it tempered between the two extremes ; neither too acute, nor too obtuse ! Indeed all the senses are exactly adapted to the exigencies of our present state. Were they strained much higher, they would be avenues of anguish ; were they much relaxt, they would be well nigh useless.

" The crowning gift, which augments the benefits accruing from all the senses, is SPEECH. Speech makes me a gainer by the eyes and ears of others ; by their ideas and observations. And what an admirable instrument for articulating the voice, and modifying it into speech, is the tongue ? This little collection of muscular fibres under the direction of the Creator, is the artificer of our words. By this we communicate the secrets of our breasts, and make our very thoughts audible. This likewise is the efficient cause of music ; it is soft as the lute, or shrill as the trumpet. As the tongue requires an easy play, it is lodged in an ample cavity. It moves under a concave roof, which gives additional vigour to the voice, as the shell of a violin to the sound of the strings.

" Wonderfully wise is the regulation of *voluntary* and *involuntary* motions. The will in some cases has no power : in others she is an absolute sovereign. If she commands, the arm is stretched, the arm is closed. How easily, how punctually are her orders obeyed ! To turn the screw, or work the lever, is laborious and wearisome. But we work the vertebræ of the neck, with all their appendant chambers ; we advance the leg, with the whole incumbent body ; we rise, we spring from the ground, and though so great a weight is raised, we meet with no difficulty or fatigue.

" That all this should be effected without any toil, by a bare act of the will, is very surprising. But that it should be done, even while we are entirely ignorant of the manner in which it is performed, is most astonishing ! Who can play a single tune upon the spinnet, with-

out learning the difference of the keys? Yet the mind touches every spring of the human machine, with the most masterly skill, though she knows nothing at all of the nature of her instrument, or the process of her operations.

"The eye of a rustic, who has no notion of optics, or any of its laws, shall lenghten and shorten its axis, dilate and contract its pupil, without the least hesitation, and with the utmost propriety: exactly adapting itself to the particular distance of objects, and the different degrees of light. By this means it performs some of the most curious experiments in the Newtonian philosophy, without the least knowledge of the science, or consciousness of its own dexterity!

"Which shall we admire most, the multitude of organs; their finished form and faultless order; or the power which the soul exercises over them? Ten thousand reins are put into her hands: and she manages all, conducts all, without the least perplexity or irregularity. Rather with a promptitude, a consistency and speed, that nothing else can equal!

"So *fearfully* and *wonderfully* are we made! Made of such complicated parts, each so nicely fashioned, and all so exactly arranged; every one executing such curious functions, and many of them operating in so mysterious a manner! And since health depends on such a numerous assemblage of moving organs; since a single secretion stopped may spoil the temperature of the fluid, a single wheel clogged may put an end to the solids; with what holy fear, should we pass the time of our sojourning here below! Trusting for continual preservation, not merely to our own care, but to the Almighty Hand, which formed the admirable machine, directs its agency, and supports its being!"

CHAPTER II.

OF THE NATURAL STATE OF THE HUMAN BODY.

1. THAT is the NATURAL STATE of the human body, wherein all parts of it duly perform their natural operations. The chief of these are, the circulation of the blood, respiration, chylification, nutrition, and motion.

2. That the blood circulates through the whole body appears hence. Any of the arteries being tied with a thread, will swell and beat between the bandage and the heart, but grow flaccid between the bandage and the extremities of the body. And if the artery be cut be-

tween the bandage and the heart, blood streams out, even to death; but if it be cut between the bandage and extremities, very little blood comes out. The vital blood therefore flows from the heart, through the arteries, toward the extremes of the body, and still out of a wider part into a narrower; out of the trunk into the branches.

Any of the larger veins being tied with a thread, swells between the extremes and the bandage, but grows flaccid between the bandage and the heart. If opened in the former part, it bleeds largely: if in the latter, scarce at all. The blood therefore flows from all the extremes, through the veins into the heart, and still from the narrower parts of the vein to the larger; from the branches to the trunk.

Upon the whole it is evident, that all the arteries are continually bringing the blood from the left ventricle of the heart, through the trunks of the arteries into their branches, and from thence to all parts of the body: and on the contrary, that all the veins, except the vena portæ, are continually bringing it back from all parts of the body, through the small branches into the larger, and thence through the trunks and vena cava into the right ventricle of the heart. So that the whole blood passes through the heart once in five or six minutes.

It is certain, that all the arteries and veins communicate or open one into the other; because, often from one, and that a small artery, all the blood shall run even unto death, not only out of the wounded limb, but from the whole body. Of such fatal examples we have a number; from an inward artery of the nose, from the gums, a finger, a tooth, a cutaneous pore enlarged, from the lachrymal point, from the wound of cupping on the skin, and even the bite of a leech. There are, therefore, of course, open ways by which the blood speedily flows from the venal, into the arterial system, and the reverse.

Late writers have pursued the globules of blood to a great length, and found several orders of them. The large ones visible to the naked eye, are globules of the *first* order. Each of these is composed of six smaller, joined together in a very regular way. But sometimes a red globule is seen loosening, and breaking into these compounding spherules. And sometimes one may perceive these running together, and beginning the composition of a new, red globule. These smaller spherules they call globules of the *second* order. But we are not to stop here. There are in the blood a great many particles six times less than these. Globules of the second order are compounded of these smaller ones, which therefore are globules of the third order.

Farther. There are innumerable blood vessels of such smallness, that none of the above mentioned globules can pass them: so that we

cannot but suppose still smaller globules. The diameter of some vessels is less than the eighth part of the diameter of a red globule: so that the particles passing through them, must be above five hundred times less than those globules. Nay, on a careful examination, we perceive vessels narrower than the tenth part of the diameter of a red globule; which consequently can transmit spherules no greater than the thousandth part of a red globule.

On the whole then, each globule of the first order is made up of six of the second: these of six of the third, those of six of the fourth: these of six of the fifth, and so on. And accordingly we find, the globules of the highest orders may be broken down into their compounding particles.

The diameter of a common red globule is about the 1938th part of an inch. The diameter of a globule of the tenth order is less than the 400,000th part of an inch.

Anatomists and physicians have generally determined the quantity of blood in the human body, to be between fifteen and twenty-five pounds. But Dr. Keil shews from many instances of profuse hæmorrhages, that a far greater quantity must be allowed. Otherwise the patient could never have furnished, or at least survived, such evacuations; the least of which exceeded the whole quantity of blood supposed to be in the body.

In reality, the quantity of blood in the human body is difficult to be determined. Bleeding to death, the usual method, can never shew what is its true quantity: because no animal can bleed longer than while the great artery is full: which will require a longer or a shorter time, as the wounded artery is smaller or greater. And the great artery must always be the first vessel that empties.

The only certain way of calculating is, to find what proportion the cavities of the vessels, of which the whole body is composed, bear to the thickness of the coats. This in the veins and arteries may be exactly found. But in the other vessels we only know the quantity of fluid they contain, by carefully evaporating as much as possible. Thus the doctor found the fluids to be in the arteries as 17 to 1; in the veins as 15,6 to 1; in the bones as 1 to 1. The least of these proportions shews the liquors to be one-half of the weight of the body. And if a calculation be made, on the proportion of the blood in the arteries, also to their coats in a body weighing one hundred and sixty pounds, there will be found one hundred pounds of blood or circulating fluid.

In a fœtus the circulation is performed in a peculiar manner. The septum, which separates the two ventricles of the heart, is pierced through with an aperture, called the *foramen ovale*, and the pulmo-

nary artery, a little after it has left the heart, sends out a tube into the descending aorta, called the COMMUNICATING CANAL. When the fœtus is born, the foramen ovale closes, and that canal dries up into a simple ligament.

The fœtus while in the womb receives little air. Its lungs therefore cannot swell and subside. They continue almost at rest: nor can they allow the blood to circulate, either in abundance, or with ease. Nature therefore has excused them from the passage of the greatest part of the blood, and has contrived the foramen ovale, by which, part of the blood of the vena cava passes through the right ventricle into the left. And by this means it is found as far on its journey, as if it had passed the lungs. But this is not all. For that blood of the cava, which missing the foramen ovale, passes from the right auricle into the right ventricle, being still too much to pass by the lungs, the communicant canal intercepts part of it, and pours it immediately into the descending aorta.

3. Respiration is performed by receiving the air into the lungs, and breathing it out alternately. In the former, the cavity of the breast is enlarged, by the sinking of the diaphragm, and the erection of the ribs, through the force of the muscles placed between them. In the latter, it is contracted; the diaphragm rising and the ribs falling again. Whenever the cavity of the breast is enlarged, the air by its weight naturally presses into it, and mixing with the blood in the vesicles of the lungs, makes it more fluid, globular and fit for motion. Air is likewise absolutely necessary in the body, to counteract the pressure of the outward air.

But if the blood in the lungs of a fœtus has not the advantage of respiration, it receives a portion of air, transmitted with its mother's blood by the umbilical vessels, to be diffused through the body. This is quite necessary, as appears hence: tie the naval string very tight, and the child dies, like a man strangled.

One use of respiration is, to push the blood from the right to the left ventricle of the heart: hence it is, that persons strangled so suddenly die, because, with respiration, the circulation of the blood ceases. And this is the true cause of the disastole of the heart: the weight of the incumbent atmosphere, being the true antagonist to all the muscles that serve both for inspiration and the contraction of the heart. As in the elevation of the ribs, a passage is opened for the blood into the lungs, so in the depression thereof, by the subsiding of the lungs and compression of the blood-vessels thereby, the blood is driven through the pulmonary vein, into the left ventricle of the heart. And this, together with the general compression of the body, by the weight of the atmosphere, is that power which causes the

blood to mount in the veins, when the force imprest on it by the heart, is nearly spent, and which forces the heart itself from its natural state of contraction, to that of dilatation.

When in an ordinary expiration, the pressure on the larynx is two ounces, the pressure on the whole internal substance of the lungs, is 14412 pounds. So vast is the extent of the surface of the vesicles, on which it was necessary the blood should be spread in the finest capillary vessels, that each globule of blood might, as it were immediately receive the whole force of the air, and thereby be broken into smaller parts, fit for secretion and circulation.

And hence we see the reason for the structure of the lungs. For since all the blood is to pass through them, in order to receive the effect of the air, and that this could not be done, unless it were difused in very small vessels: it was necessary the surface on which they were to be spread, should be proportioned to their number. And this is admirably well provided for, by the fabric of the lungs.

If the diameter of the trachea at the time of every expiration were the same in all, and the weight of the air always equal, the pressure on the lungs would be always the same. But as the difference between its least and greatest gravity, is no less than a tenth part of the whole, that pressure is likewise greater by a tenth part at some time than it is at others.

This is a difference which the asthmatic must sensibly feel; especially as they breathe thicker, that is, every expiration is performed in less time. In truth, these feel a difference in the air, upon the greatest rise and fall of the barometer, equal to above one third of its pressure in ordinary breathing.

The alternate dilatation and contraction of the thorax are so necessary to animal life, that there is no animal without this, or something analogous to it. Fishes and insects have no dilatable thorax. But fishes have gills, which receive and expel the water alternately, whereby the blood-vessels suffer the same alterations of dimension as those in our lungs do. And insects have air-vessels distributed through the whole trunk of their bodies. By these they communicate with the external air through several vent-holes, to which are fastened so many wind-pipes which send branches to all parts, and seem to accompany the blood-vessels all over the body, as they do in our lungs only. And hereby in every inspiration the whole body is dilated, and in every expiration compressed.

But may it not be doubted, whether the primary end of respiration be not to supply the whole animal machine with the ethereal fire, a particle of which is connected with every particle of air? Is not this detached from it by the action of the lungs, and thence communicated

to every part of the body? And is not this the true vital flame, the original source of life and motion?*

4. Chylification is preceded by digestion, which is much illustrated by Mr. Papin's digester. This is a vessel wherein meat is put, with just as much water as will fill it. Then the lid is screwed on so close, as to admit of no external air. The meat herein is by the flame of a small lamp, in six or eight minutes brought to a perfect pulp. In a few minutes more the hardest bones are reduced to a jelly. No air entering, the succussions caused by the air, enclosed in the flesh, resolve the whole into one homogenous body. It is just so in digestion. In proportion to its heat, the stomach does the very same thing as the digester.

Add to this, that the muscular coat of the stomach continually contracting, and pressing its contents by its peristaltic motion, occasions a more intimate mixture, and works the more fluid parts, through the pylorus into the duodenum. Along the sides of this and the other small intestines the lacteals are planted: into the minute orifices whereof, the chyle or finer part of the mass is received. The lacteal veins of the first kind discharge themselves into the glands of the basis of the mesentery. The chyle is afterward received by the lacteals of the second kind, and conveyed into glands between the two tendons of the diaphragm. And hence it is carried to the heart, where it mixes with the blood.

5. By the perpetual motion of the fluids, especially in the minute vessels, as well as the constant action of the muscles, small particles are continually worn off, from the solids of the body. The fluids likewise are continually diminishing. And hence every animal body, by the very condition of its frame, is liable to destruction. To prevent this, a restitution must be made to the juices and solids of the body, equal and similar to what is lost. And this we call nutrition.

It seems to be performed thus. The blood forcibly thrown by the

*This was a most ingenious anticipation of the discovery of the decomposition of oxygen, and inflammable air in the lungs, which is now pretty satisfactorily ascertained to be the origin of animal heat, it is here termed, the true vital flame, the original source of life and motion. It is doubtless the true vital heat, and a very principal source of life and motion. What is meant by the expression, ethereal fire, appears to be the basis of heat, or what is termed in the new nomenclature caloric, or the elementary matter of heat. Sometimes it is termed fire in the dormant state, or latent heat. On the first discovery of the composition of air, it was termed phlogiston, or the capacity of combustion. Such multifarious expression, rendered it necessary in forming the new nomenclature to assume a general term, which should imply the basis, or element of heat, fire, flame, &c. which are considered as various states or modifications of caloric.

heart into the arteries, endeavours to go out every way through the pores. But these are usually too small to give its particles a free passage. They can only pass where any of the pores are open. Here one will naturally follow another in a line, and constitute a fibre or part of a fibre. When as much is thus added to one end of the fibre, as is wasted at the other, the body is *nourished;* when more is added than is wasted, we are said to *grow*.

We see then how absolutely necessary food is to repair the constant decay of the body: so that few men or women can live without it, above five or six days. And yet the abstaining from it for a season, has its use. Indeed great is the efficacy of abstinence, both in prolonging life beyond its usual period, and in the cure of many stubborn disorders.

Lewis Cornaro, a nobleman of Venice, after all other means had failed, so that his life was despaired of at forty, recovered and lived to near a hundred, by mere dint of abstinence.

It is surprising to observe, to what an age those ancient christians lived, who retired from the fury of persecution into the deserts of Arabia and Egypt. They drank only water, and took no other food than 12 ounces of bread in 24 hours. On this St. Anthony lived 105 years, Epiphanius 115, Simon Stylites 112, and Romuald 120.

Among animals we see surprising instances of long abstinence. Several species pass four, five, or six months every year without eating or drinking. So tortoises and dormice regularly retire at the season to their respective cells. Some kinds get into ruins, or the hollows of rocks; others into clefts of trees. Some sleep in holes under the earth; others bury themselves under water.

The serpent kind bear abstinence to a miracle. Rattle snakes will subsist many months without food. Dr. Shaw saw two Egyptian serpents, which had been kept in a bottle five years (on a small quantity of sand wherein they coiled themselves up,) without any sort of food. Yet when he saw them they had just cast their skins, and were as lively as if just taken.

There have been instances even of men passing several months, with scarce any sustenance. So Samuel Chilton, of Tinbury, near Bath, in the year 1693, 1694, and 1695, slept sometimes four months, and sometimes above six together, with very little food: and six weeks without any, but a little tent conveyed with a quill through his teeth.

And since this, John Ferguson, of Killmelford, in Argyleshire, about eighteen years ago, overheated himself, drank largely of cold water, and fell asleep. He slept for four and twenty hours, and waked in a high fever; ever since his stomach loathes, and can retain no kind of aliment but water. A neighbouring gentlemen to whom his father is tenant, locked him up for twenty days, supplying him daily with water.

and taking care that he should have no other food. But it made no difference, either in his look or strength. He is now six and thirty years of age, of a fresh complexion, and as strong as any common man.

Still more strange is the case of Gilbert Jackson. About fifteen years of age, in February 1716, he was seized with a violent fever: it returned in April for three weeks, and again on the 10th of June: he then lost his speech, his stomach, and the use of his limbs, and could not be persuaded either to eat or drink any thing. May the 17th, 1717, his fever left him, but still he was deprived of speech and the use of his limbs, and took no food whatever. June 30th, he was seized with a fever again, and the next day recovered his speech, but without eating or drinking, or the use of his limbs. On the 11th of October he recovered his health, with the use of one of his legs, but neither ate nor drank; only sometimes washed his mouth with water.

On the 18th of June, 1713, the fever returned and lasted till September. He then recovered, and continued in pretty good health, and was fresh coloured, but took no kind of meat or drink. On the 9th of June, 1719, he was again seized with a severe fever. On the 10th, at night, his father prevailed on him to take a spoonful of milk, boiled with oatmeal. It stuck so long in his throat, that his parents feared he had been choaked; but ever since that time he has taken food, though so little, that a half-penny loaf serves him for eight days. All the time he fasted, he had no evacuation, either by stool or urine: and it was fourteen days after he began to eat, before he had any. He is now in pretty good health.

I suppose such another instance as this, has scarce been known in the memory of man.

It is not improbable, that the air itself furnishes some nutritive particles. It is certain, there are substances of all kinds, floating in the atmosphere. And that an animal body may be nourished hereby, is evident in the case of vipers. These, if taken when first brought forth, and kept from every thing but air, will yet grow considerably in a few days.

6. As without respiration and nutrition we cannot live at all, so without SENSE, life would be like death. In every sensation there is, 1. An outward object. 2. Its action in the organ of sense. 3. A perception of it in the mind. The action of the object on the organ, is by means of the nerves communicated to the brain. And then, not otherwise, the perception follows. But how, none but He that made man can explain.

7. In SIGHT, the action on the organ is performed just in the manner of that in a camera obscura. The rays of light reaching from the surface of bodies to the eye, variously penetrate the coats and

humours of it, and paint on the bottom of the eye the images of the things which we see. This is communicated by the optic nerve to the brain, and then the perception, which is properly sight, follows. But the eye has many advantages above a camera obscura: not only as it can be moved various ways, by the help of its muscles; but also as the pupil, by the help of the iris, is instantly either dilated or constringed, according to the degree of light. The eye likewise accommodates itself to the various distances of the objects, the bottom of the eye approaching to or receding from the crystalline humour, as the object is nearer or farther off.

8. SOUND is a tremulous motion of the air, produced by the stroke or collision of bodies. HEARING is performed in the following manner. The undulating air enters the outward cavity of the ear, and then strikes upon the drum; from which the motion is communicated to the little bones within and the air contained in the inner cavity. This, by means of the nerve, conveys it to the brain, and then follows the perception which we term HEARING.

9. The fine effluvia which spread every way from odorous bodies, ascending with the air into the nostrils, variously twitch the filaments of the olfactory nerves, according to the variety of their natures. When this motion is by those nerves communicated to the brain, the perception follows which is called SMELLING.

10. It was observed before, that the surface of the tongue is filled with small *papillæ*, which are no other than fine ramifications of the gustatory nerve. These are variously moved, by the particles of meat and drink. And this motion being by that nerve transmitted to the brain, that perception arises which we style TASTING.

11. The organ of FEELING is the skin in general, with which innumerable nervous *papillæ* are interwoven, which being moved by the slightest touch of other bodies, convey that motion to the brain. But these papillæ abound in all the extremities, particularly the palms of the hand, and the tips of the fingers. And hence it is, that the sense of feeling is far more exquisite in those, than in other parts.

12. Nearly allied to the senses are the natural appetites, particularly HUNGER and THIRST. The usual way of accounting for them is this. When the food, now reduced to a pulp, is expressed out of the stomach, it is of course contracted by its muscular coat. This causes the inner coat to lie in folds; which by means of the peristaltic motion, rubbing lightly on each other, occasion the uneasy sensation which we term HUNGER. This is felt first in the upper orifice which is first evacuated. But as by degrees the rest of the contents are expelled, this rubbing of the membranes on each other spreads over the whole stomach, and renders our hunger more urgent.

This uneasy sensation is increased by the acidity, which the blood in the arteries of the stomach contracts through long abstinence, its soft, balsamic parts having been all drawn off. Likewise its velocity is considerably augmented, when we have not eaten for some time.

Hence it is, that hunger, if it continues long, will occasion a violent fever: that young persons, and those who labour hard, or are of a bilious constitution, are soonest hungry: whereas those whose humours are thick and viscid, are not so soon incommoded therewith.

13. Hot vapours ascending from the stomach, and drying the throat and mouth, are supposed to be the occasion of that uneasy sensation, which we term THIRST.

I say, are supposed. For I apprehend nothing can be known with any certainty upon the head. In like manner it is supposed, that we are then awake, when the nerves are braced and filled with animal spirits; and that when they are unbraced and empty, we sleep. But who can give any satisfactory account of sleep? Some ascribe it to the stoppage of the nerves: some to the quiescency, and others to a deficiency, of the animal spirits. The truth is, we are ignorant of the whole affair; and no more understand sleep than we do death.

But this we know, that during sleep several functions are suspended, the organs of sense are at rest, the muscles are quiescent, so that hardly any spirits flow through them. The fibres of the nerves are little changed, and an equilibrium obtains throughout. There is no difference of pressure on the vessels, nor of velocity in the humours, which circulate equally through all the canals. Mean time, all disturbing causes being at rest, the wasted humours are restored, and the particles supplied, which were worn off the solids.

We may observe farther, that when the head is hot, and the feet cold, we cannot sleep; that perspiration is twice as great while we sleep as while we are awake; that too much sleep makes the senses dull, the memory weak, and the whole body listless; that sleep will for a considerable time supply the place of meat and drink; that a fœtus sleeps always; children much; youths more than adults, and they than old men.

To speak a little more particularly. While we are awake there is a continual motion of the voluntary muscles, of the parts subservient to sense, and to the affections, all which stimulate the nerves, blood-vessels and heart. Thus the finer parts of the blood are continually wasted, whence weariness ensues: and if the vigilance be continued, a feverish heat and sensible loss of strength.

As the night advances, a weight falls on the large muscles and their tendons; and the mind becomes heavy. The powers that hold the body erect, begin to shrink from their office; the eyelids close; the head nods, and we take less notice of outward objects, till at length

all the thoughts are in confusion, and a sort of delirium ensues, from whence there is a transition to sleep, not known to us. This is hastened by darkness, composure of mind, and absence of irritation from all parts of the body.

Again; whatever weakens the natural powers, inclines to and increases sleep: such as loss of blood, cooling medicines, yea the cold of the external air. Add to these, whatever calls off the quantity of blood flowing to the heart, as warm bathing of the feet, a plentiful ingestion of food into the stomach: likewise whatever lessens the motions of the spirits, whether in the brain, or stomach, heart, or arteries. On the contrary, some hot medicines induce sleep, by causing a greater afflux of blood to the brain. The same effect have some fevers; as also fatness, and whatever else retards the venal blood. In all these cases, the blood collected in the head compresses the brain, so as to lessen the course of the spirits into the nerves.

Sleepiness is likewise produced by any compression of the brain, whether from extravasated blood, a depressed part of some bones, or a collection of serous water within the ventricles.

Sleep therefore sometimes rises from a defect of the spirits: always from a collapsing of the nervous fibres, through which the spirits pass from their fountain to all parts of the body.

It is hindered by intense thought, pain of body and strong emotions of mind: all which urge the spirits on, and prevent the nervous fibres from collapsing.

In sleep, the heart is gradually restored from its quick and almost feverish pulsation, to its slow and calm motion: the breathing is slower and smaller, the motion of the stomach and intestines, the digestion of the aliments and the progression of the fæces are diminished. At the same time the thinner juices move more slowly, while the more gross are called together, the fat is accumulated in its cells, and the nutritive particles adhere more plentifully to the inner surfaces of the small vessels and the sides of the fibres. Thus while the spirits are secreted with a less consumption, they are by degrees accumulated in the brain, so as to distend and fill the collapsed nerves. And then we awake out of sleep.

Let us consider in another view these remarkable incidents of our frame, SLEEP and DREAMS: so remarkable, that they are a kind of experimental mystery, a standing miracle. Behold the most vigorous constitution, when resigned to the slumbers of the night. Its activity is oppressed with indolence; its strength suffers a temporary annihilation. The nerves are like a bow unstrung, the whole animal like a motionless log. Behold a person of the most delicate sensations and amiable dispositions. His eyes, if wide open, discern no light, distinguish no objects. His ears, with the organs unimpaired, perceive

not the sounds that are round about them. The exquisitely fine sense of feeling is overwhelmed with an utter stupefaction. Where are his social affections? He knows not the father that begat him, the friend that is as his own soul. Behold the most ingenious scholar, whose judgment traces the most intricate sciences, whose taste relishes all the beauties of composition. The thinking faculties are unhinged, and instead of close-connected reasonings, there is nothing but a disjointed huddle of absurd ideas. Instead of well-digested principles, nothing but a disorderly jumble of crude conceptions.

Yet no sooner does he awake, than he is possest of all his former endowments. His sinews are braced and fit for action, his senses alert and keen. The frozen affections melt with tenderness: the romantic visionary is again the master of reason. And, what is beyond measure surprising, the intoxicated mind does not work itself sober by slow degrees; but, in the twinkling of an eye, is possessed of all its faculties! Why does not the numbness, which seized the animal powers, chain the limbs perpetually? Why does not the stupor, that deadens all the senses, hold fast its possession? When the thoughts are once disadjusted, why are they not always in confusion? How is it, that they are rallied in a moment, and reduced from the wildest irregularity to the most orderly array? From an inactivity resembling death, and from extravagancies little differing from madness, how suddenly is the body restored to vigour and agility? How instantaneously is the mind re-established in sedateness and harmony! Surely "this is the Lord's doing: and it is marvellous in our eyes!"

14. That all MOTION is performed by means of the muscles, all men are now agreed. And it is supposed that the motions of the muscles proceed from the influx of the animal spirits; which entering them by means of the nerves, swell and shorten the belly of the muscle, and thereby draw the extremities together, and move the parts connected therewith. But all this likewise is mere conjecture. God only knows his own work.

15. That some motions are *voluntary*, and some are not, is another amazing proof of the Creator's wisdom. Those which are absolutely necessary for the conservation of the machine, as the beating of the pulse, and the circulation of the blood, go on by a kind of mechanic law, which no way depends upon our will: while a thousand other motions begin and end, by a single act of our will, when we please. But how this bodily motion is connected with that act of our mind, who is able to explain?

16. There is a manifest congruity between the stature of man, and his age, during the time of his growth. And as five feet and a half may be thought the ordinary height of man, so may seventy years the

ordinary period of his life. Yet some vastly exceed in both respects. And as we know Thomas Parre and Henry Jenkins completed double that usual term of life, so we have no reason to question, that some have doubled the common stature of man. Walter Parsons, king James the first's porter, was full seven feet, seven inches high. Mr. Ray saw a man at Bruges, who was eight feet and a half; all his limbs well shaped, and his strength proportionable. Becanus says, he saw a youth almost nine feet high; a man near ten, and a woman quite ten feet. Pliny mentions several men of the same height in his age. Yea, Thevenot tells us, that he met a Spanish merchant on the coast of Africa, who had in a coffer the skull and bones of an American giant, which he brought with him from that country, who was eleven feet, five inches in height, and died in the year 1559.

From these warrantable accounts we learn, that there have been men eleven or twelve feet high, which equals, if not exceeds, the stature of the tallest giant mentioned in scripture. The height of Goliah was but six cubits and a span, which is only nine feet, nine inches. Indeed the bedstead of Og, the king of Bashan, is said to have been nine cubits in length. But his bed must have been longer than his body: we may fairly allow nine inches above his head, and as much below his feet. And making this deduction, he was not above twelve feet high: much of the same stature with the giant, whose forehead bone is still kept in the medicine school at Leyden.

Is this deviation from the common stature of man by largeness, more remarkable than its opposite? The deviation from it by littleness, which has been observed in some instances? Such was the dwarf, who lived for several years in the palace of the king of Poland. His parents were healthy, strong peasants, who affirmed, that at his birth he weighed scarce a pound and a quarter; that he was presented on a plate to be baptized, and for a long time had a wooden shoe for his bed. When 18 months old, he could speak some words; when two years old, he could walk almost without help. His shoes were then just an inch and a half long. When he was six years of age, the king of Poland gave him the name of Bebe, and kept him in his palace. His height was then fifteen inches, and he weighed thirteen pounds. He was in perfect health, his person was agreeable and well proportioned; but there was little appearance of understanding. He had no sense of religion, was incapable of reasoning, and could learn neither music nor dancing. Yet he was susceptible of passions in a high degree, anger and jealousy in particular. When sixteen years old, he was 29 inches high, being still healthy and well proportioned: but from that time his health declined: yet he grew four inches in the four succeeding years. At 21 he was shrunk and decrepit; and at 22 it was with difficulty he could walk a hundred

steps. In the 23d year he fell into a kind of lethargy, and in a few days died, as it were of old age.

17. The two most eminent instances of longevity in England were Thomas Parre and Henry Jenkins. Thomas Parre was a poor countryman of Shropshire, whence he was brought up to London, by Thomas, earl of Arundel. At the age of 120 he married a widow: at 130 he could do any husbandry work, even threshing of corn, although, soon after, his sight began to fail; nor had he the use of his memory, or but in a small degree for several years before he died: but he retained his hearing and apprehension to the last. He used to eat often, by day and by night, of milk, old cheese with coarse bread, whey and small beer. He died at the age of 152 years and 9 months. He might have lived much longer, but coming out of a clear, thin and free air to London, and from a plain country diet, to that of a splendid family, where he fed high, and drank the best wines, the natural functions were overcharged, and death could not but soon ensue.

Henry Jenkins called at my house, I asked how old he was? he paused and said, "about 162, or 163." I asked what was the first public transaction he remembered? he said, "the battle of Flowdenfield, being then 11 or 12 years old."

For many years he was a fisherman, and used to wade in the streams. After he was a hundred years old he frequently swam in the rivers. The latter part of his life he was obliged to beg. He died at Ellerton upon Swale, in Yorkshire, December 8, 1670: having lived, supposing him to have been 12 years old, at the battle of Flowdenfield, which was fought September the 9th, 1513, a hundred and sixty-nine years, that is, sixteen longer than Thomas Parre.

CHAPTER III.

OF THE PRETERNATURAL STATE OF THE HUMAN BODY.

1. WHEN the structure or disposition of the parts of the body is so disturbed and disordered, that the natural operations are no longer performed, or not in the manner they ought: this is a preternatural state of the body, otherwise termed a disease.

2. There cannot but be a great variety of diseases, whether we consider the manner, wherein that structure or disposition is disturbed, the part wherein each disease has its seat, or the various effects and circumstances of them. Some diseases only hurt the use of the parts; some wholly *destroy* it. Some affect this or that part;

others the whole body. Some disorder the body, some the mind; and others both mind and body.

3. But they are all reducible to three classes, those of the SOLIDS, of the FLUIDS, and of *both*. The solid parts may be bruised, wounded, swelled, or removed out of their natural place.

It is a wonderful provision which nature makes in one of the most dreadful calamities incident to the solids. When a bone is broken, let it only be replaced and preserved in that situation, and nature does the rest, by supplying the divided parts with a callus.

This oozes out from the small arteries and bony fibres of the divided parts, in form of a jelly, and soon fills up the cavities between them. It soon grows cartilaginous, afterwards bony, and joins the fractured parts so firmly, that the bone will be more easily broken in any other part than in that.

A callus of a different kind is formed on our hands and feet. This is composed of several layers of particles loosely connected. These, if steeped in fair water, easily separate; and then are found, if viewed through a microscope, to be all of one shape, resembling that of a weaver's shuttle, broad in the middle and pointed at each end. Being steeped again, they divide into a great number of smaller particles, all of the same figure with the first.

The thickness of the skin in the hands of those who labour hard is wholly owing to vast numbers of these particles which combine together, but so loosely that they are easily separated on moistening. That thick skin is composed of several layers of different thickness, which have been added from time to time: each of which layers is only a congeries of almost an infinity of these particles.

But people who labour ever so hard, will have little callus on their hands if they wash them often. The washing the hands daily rubs off a great quantity of these scales. Indeed it is surprising to see how large a quantity of them is daily thrown off from our hands and feet, though from no other part of the body. We may learn from this the great bounty of nature, in so carefully supplying the parts designed for walking or labour, with an additional matter for their defence, which is not in any other part of the body.

4. The diseases of the FLUIDS lie chiefly in the blood, when it is either too thick and sizy, whereby its motion becomes too languid and slow, whence spring the diseases owing to obstruction: or too thin. From the former cause arise leprosies, scirrhus's lethargies, melancholy, hysteric affections; and if at the same time it abounds in acid salts, the sharp points of these tear the tender fibres, and occasion the scurvy, king's-evil, consumption, with a whole train of painful distempers.—Fevers frequently arise from the too great thinness in the blood.

The *plague* is not an European disease. It is properly a disease of Asia, where it is epidemical,* and is never known elsewhere, but by importation from thence. The small-pox also is an exotic disease, and was not known in Europe, or even Asia Minor, till a spice trade was opened by the later princes of Egypt, to the remotest part of the East-Indies. Thence it originally came, and there it rages at this day.

5. As to the diseases ascribed to the ANIMAL SPIRITS, some are thought to proceed from the suppression or diminution of their motion, as apoplexies and palsies; some from their excessive or irregular motion, as madness, convulsions, epilepsies.

I know not whether the gentlemen of the faculty would not term the following, "a disease of the animal spirits." Donald Monro, at Strathbogie, in Scotland, imitates unawares all the motions of those he is with. He is a little, slender, old man, and was subject to this infirmity from his infancy. He is loath to have it observed, and therefore casts down his eyes in the streets, and turns them aside when in company. We had made several trials before he perceived it, and afterwards had much ado to make him stay. He imitated not only our scratching our heads, but the wringing our hands, and every other motion. We needed not to persuade him to be covered; for he still covered and uncovered as we did: and all so exactly, and yet with such a natural and unaffected air, that none could suspect he did it designedly. When we held both his hands, and caused another to make such motions, he struggled to get free. But when we would have known more particularly, how he found himself affected, he would only give us this simple answer, "that it vexed his heart and his brain."

But to what class shall we refer the disease of Ann Jackson? She was born at Waterford, of English parents both said to be sound and healthy, and from three years old, had horns growing on various

* The plague appears, from various considerations, to be a high grade of bilious fever, and not peculiar and endemial as has been thought by many. It is a bilious malignant fever, accompanied with black vomiting, the same as the black fever of Russia, the putrid fever of Germany, the spotted fever of England, and the yellow fever of America. It is the same disease, and denominated, from mere local circumstances, black, yellow, &c. in general, as it leaves the victim black, yellow, spotted, &c.

The plague has been considered as absolutely contagious, and to mow down all that came within its sphere. But this has been found to be a mistake. Its contagiousness seems to depend like other epidemics, on a predisposition in the subject to receive it. This predisposition seems to be derived from certain qualifications of the atmosphere, as it abounds more or less with the vegetable, and putrid miasmatta. So the susceptibility of contagion appears to be greater or less, and more or less general.

parts of her body. She is now thirteen or fourteen: the horns grow chiefly about the joints; they are fastened to the skin like warts, and about the roots resemble them much in substance, but toward the end are much harder. At the end of each finger and toe is one, as long as the finger or toe itself, rising a little between the nail and flesh, and bending again like a turkey's claw. On the joints of each finger, and toe are smaller ones, which sometimes fall off, but others come in their place. Round her knees and elbows are many; two in particular at each elbow, which twist like ram's horns. At each ear grows one: yet she eats and drinks heartily, sleeps soundly, and performs all the offices of nature, like other healthy persons.

6. Such are the proximate causes of diseases. As to the remote, the chief are these, 1. Intemperance in meat or drink, either with regard to the quantity or quality, 2. Want of exercise, or excess therein. 3. Immoderate sleep or watching. 4. Unwholesome air. 5. The diminution of some natural evacuation. 6. Irregular passions. All or any of these affect the temperature and motion of the blood and spirits.

7. But it can scarcely be conceived, after all that has been said and wrote, on almost every subject, how very little is known to this day, concerning the causes of diseases. In most cases the skilful physicians acknowledge they have nothing but conjectures to offer. We may give a specimen with regard to fevers, the most common of all distempers. These are of various kinds: at present we will speak of intermitting fevers only. Most of these agree in the following symptoms. During the approach of the fit, cold and shivering seize the body, with a small and slow pulse. Heat succeeds, with a quick, strong, hard pulse, followed by sweat and a softer pulse. These fits return at stated times.

It is supposed, that these changes in the blood arise from some foreign matter mixt with it, which it cannot readily assimilate, and which therefore must in some measure hinder its motion: perhaps because the particles of it are too large, too long, or branching out. When the circulation is hindered or retarded, chillness naturally follows. And if these particles, sticking in the finer passages, are prest on by the affluent blood, this will occasion both a shock and a tremor of the muscles, and make the pulse more weak and slow. But when they are at length broken and comminuted, by the continued afflux of the blood, it will flow more violently, and of course occasion heat, which driving the blood to the surface of the body, many of its thinner particles will burst through the pores, in the form of sweat. As to the fevers returning at stated times, it is supposed, the peccant matter is generated from time to time, and mingled with the blood afresh; whence the same symptoms of course return, and that with more or

less violence, as more or less of that matter is generated. And as this is done more swiftly or slowly, the fever returns in one, two, or three days. But all this is mere conjecture. It may be so; and it may not. So that though we may guess much, we know nothing about it.

8. It is sufficient for us to know how we may avoid diseases, whether we can account for them or not. To this end we should avoid whatever, in meat, drink, motion, or rest, is likely to produce any considerable change in the blood. The body likewise should be as far as possible accustomed to bear some change of food, air, and other externals, that if we should at any time be constrained to make such a change, no ill consequence may ensue. But no precise rule can be laid down which will suit all constitutions. Every man must consult his own reason and experience, and carefully follow them.

A most unaccountable method of removing many diseases, was that of the famous Mr. Greatrix. "I give you nothing concerning him," says Mr. Boyle, "but from eye-witnesses. My own brother, some time since, was seized with a violent pain in his head and back. Mr. Greatrix coming by accident to our house, gave present ease to his head by stroking it. He then stroked his back: the pain immediately fled to his right thigh. He pursued it with his hand to the knee, ankle, foot, toe, then he stroked this, and it was gone.

"My uncle's daughter was seized with a pain in her knees, which occasioned a white swelling. She tried many remedies without effect, for six or seven years. Mr. Greatrix then coming to Dublin, my aunt brought her to him. He stroked her knees, and the pain fled downward from his hands, till he drove it out of her toes. And in a little time the white swelling went away.

"I had an acquaintance, who, after a fever, was very deaf, and had a violent pain in her ears. Mr. Greatrix put some spittle in her ears and rubbed them, which cured both the pain and deafness.

"Another told me, that when a child, she was extremely troubled with the king's evil. She tried many remedies in vain; but Mr. Greatrix stroked and perfectly cured her. A smith near us had two daughters troubled with the same distemper. One of these had a running sore in the thigh, the other in the arm: he cured them both. He cured all kinds of hysteric fits. He likewise cured the falling sickness, and without any relapse, provided he could see the patient in three or four fits."

9. As long as the soul and body are united, a man is said to be ALIVE. But it is extremely difficult to determine the precise time at which life ceases, or what that is which is absolutely necessary to the continuance of it. Is respiration? But when this is entirely ceased, as is the case in a person strangled, blow strongly into the lungs, and they play again; which shews he was not dead before. Is the beat-

ing of the heart? But when this also is ceased, in the forementioned case, take the same method, and when the lungs begin to play, the heart begins to beat anew. Is the circulation of the blood? But persons drowned, who have been so long under water, as to have no pulse remaining in any artery, and consequently no circulation, have recovered by the use of proper means, and lived many years after. Is the fluidity of the blood? Nay, but it is a common thing in Sweden, to recover to life one who has been twenty-four hours under water: and who not only has no pulse, but is as stiff all over, as any dead corpse can be. What then is death? Undoubtedly it is the separation of the soul and body. But there are many cases wherein none but God can tell the moment wherein they separate.

Many who *seem* to be dead, may be recovered. A person suffocated by the steam of coals, set on fire in the pit, fell down as dead. He lay between half an hour and three quarters, and was then drawn up, his eyes staring, his mouth gaping, his skin cold: not the least breathing being perceivable, nor the least pulse either in his heart or arteries.

A surgeon applied his mouth to that of the patient, and by blowing strongly, holding the nostrils at the same time, raised the chest by his breath. Immediately he felt six or seven quick beats of the heart; the lungs began to play, and soon after the pulse was felt in the arteries. He then opened a vein, which at first bled drop by drop, but in awhile bled freely. Mean time he caused him to be pulled and rubbed. In an hour he began to come to himself; in four hours walked home, and in four days returned to his work.

Wherever the solids are whole, and their tone unimpaired, where the juices are not corrupted, where there is the least remains of animal heat, it would be wrong not to try this experiment. This takes in a few diseases, and many accidents. Among the first are many that cause sudden deaths, as apoplexies and fits of various kinds. In many of these it might be of use to apply this method: and in various casualties, such as suffocations from the damps of mines and coal-pits, the condensed air of long unopened wells, the noxious vapours of fermenting liquors received from a narrow vent, the steam of burning charcoal, arsenical effluvia, or those of sulphureous mineral acids. And perhaps those who seem to be struck dead by lightning, or any violent agitation of the passions, as joy, fear, anger, surprise, might frequently be recovered by this simple process.

The animal machine is like a clock the wheels whereof may be in ever so good order, the mechanism complete in every part, and wound up to the full pitch; yet without some impulse communicated to the pendulum, the whole continues motionless.

Thus, in these accidents, the solids are whole and elastic, and the juices no otherwise vitiated, than by a short stagnation from the quiescence of that moving *something*, which enables matter in animated bodies, to overcome the resistance of the medium it acts in. Inflating the lungs, and thus communicating motion to the heart, like giving the first vibration to a pendulum, enables this *something* to resume the government of the fabric, and actuate its organs afresh. It has been suggested, that a pair of bellows might be applied better than a man's mouth. But, 1. Bellows may not be at hand: 2. The lungs of one man may safely bear as great a force, as the lungs of another can exert, which by the bellows cannot always be determined: 3. The warmth and moisture of the breath may likewise be of use.

But what is properly a *natural death?* From the very birth, every vessel in the human body grows stiffer and stiffer by the adhesion of more and more earthly particles to its inner surface. Not only solid food supplies it with these, but every fluid that circulates through it. Hereby more and more of the small vessels are so filled up, as to be no longer pervious. In proportion, the coats of the larger vessels grow harder, and their cavities narrower. Hence the dryness and stiffness of all the parts, which are observable in old age. By this means, more and more of the vessels are destroyed, the finer fluids secerned in less quantity, the concoctions weakened, and the reparation of the decayed and injured parts prevented. So that only the coarser juices continue to run slowly through the larger vessels. Soon these also not only become narrow, but stiff, bony, and unelastic, till even the great artery having lost its spring, can propel the blood no longer. And then follows death by old age which is a purely *natural* death. But this is a very rare case: it is seldom life is so long protracted, the lamp of life being easily blown out, when it burns with so feeble a flame. So that the age of man seldom exceeds three score years and ten before dust returns to dust.

The term of life can be prolonged but a very little time, by any art we can use. A few only have lived beyond the ordinary duration of human existence; such as Parre and Jenkins: yet these men used no particular arts to prolong life; on the contrary, they were peasants, accustomed to the greatest fatigues, and who had no settled rules. Indeed, if we consider that the European, the negro, the Chinese, and the American, the civilized man, and the savage, the rich and the poor, the inhabitant of the city, and of the country, though all so different in other respects, are yet entirely similar in the period allotted them for living; if we consider that neither the difference of race, of climate, of nourishment, of convenience, or of soil, makes any difference in the term of life; if we consider that those men, who live

upon raw flesh, or dried fishes, upon sage or rice, upon cassava, or upon roots, nevertheless live as long as those who are fed upon bread and meat; we shall readily acknowledge, that the duration of life depends neither upon habit, customs, nor the quantity of food, and that nothing can change the laws of that mechanism, which regulates the number of our years.

If there be any difference in the different periods of man's existence, it ought principally to be ascribed to the quality of the air. It has been observed, that in elevated situations there have been found more old people than in those that were low. The mountains of Scotland, Wales, Auvergne and Switzerland, have furnished more instances of extreme old age, than the plains of Holland, Flanders, Germany, or Poland. But in general, the duration of life is nearly the same in most countries. Man if not cut off by accidental diseases, is generally found to live ninety or a hundred years. Our ancestors did not live beyond that date; and since the time of David, this term has had but little alteration.

If we be asked how, in the beginning, men lived so much longer than at present, and by what means their lives were extended to nine hundred and thirty, or even nine hundred and sixty years, it may be answered, that the productions of the earth, upon which they fed, might be of a different nature at that time, from what they are at present. But perhaps it is better to say, that the term was abridged by divine command, in order to keep the earth from being over-stocked with human inhabitants; since, if every person were now to live and generate for nine hundred years, mankind would be increased to such a degree, that there would be no room for subsistence; so that the plan of Providence would be altered; which is seen not to produce life, without providing a proper supply!

But to whatever extent life may be prolonged, or however some may have delayed the effects of age, death is the certain goal to which all are hastening. All the causes of decay, which have been mentioned, contribute to bring on this dreadful dissolution. However, nature approaches to this awful period, by slow and imperceptible degrees, life is consuming day after day, and some one of our faculties, or vital principles, is every hour dying before the rest; so that death is only the last shade in the picture: and it is probable, that man suffers a greater change in going from youth to age, than from age into the grave. When we first begin to live, our lives may be scarcely said to be our own; as the child grows, life increases in the same proportion, and is at its height in the prime of manhood. But as soon as the body begins to decrease, life decreases also: for as the human frame diminishes, and its juices circulate in smaller quantity, life diminishes

and circulates with less vigour; so that as we begin to live by degrees, we begin to die in the same manner.

Why then should we fear *death*, if our lives have been such as not to make *eternity* dreadful? Why should we fear that moment which is prepared by a thousand other moments of the same kind, the first pangs of sickness being probably greater than the last struggles of departure? Death, in most persons, is as calmly endured, as the disorder that brings it on. If we inquire from those, whose business it is to attend the sick, and the dying, we shall find, that, except in a very few acute cases, where the patient dies in agonies, the greatest number die quietly, and seemingly without pain. And even the agonies of the former rather terrify the spectators, than torment the the patient; for how many have we seen, who have been accidentally relieved from this extremity, and yet had no memory of what they then endured? In fact, they had ceased to live, during that time when they ceased to have sensation; and their pains were only those of which they had an idea.

The greatest number of mankind die, therefore, without sensation: and of those few that still preserve their faculties to the last moment, there is scarcely one that does not also preserve the hopes of still out-living his disorder. Nature, for the happiness of man, has rendered this sentiment stronger than his reason. A person dying of an incurable disorder, which he must know to be so, by frequent examples of his case; which he perceives to be so, by the inquietude of all around him; by the tears of his friends, and the departure, or the face of the physician, is nevertheless, still in hopes of getting over it. His interest is so great, that he only attends to his own representations; the judgment of others is considered as a hasty conclusion; and while death every moment makes new inroads upon his constitution, and destroys life in some part, hope still seems to escape the universal ruin, and is the last that submits to the blow.

Death, therefore, is not the terrible thing which we suppose it to be. It is a spectre which frights us at a distance, but which disappears when we come to approach it more closely. Our ideas of its terrors are conceived in prejudice, and dressed up in fancy; we regard it not only as the greatest misfortune, but as also an evil accompanied with the most excruciating tortures: we have even increased our apprehensions, by reasoning on the extent of our sufferings. It must be dreadful, say some, since it is sufficient to separate the soul from the body; it must be long, since our sufferings are proportioned to the succession of our ideas; and these being painful, must succeed each other with extreme rapidity. In this manner false philosophy labours to augment the miseries of our nature, and to aggravate that

period, which nature has kindly covered with insensibility. Neither the mind, nor the body, can suffer these calamities; the mind is, at that time, mostly without ideas, and the body too much enfeebled, to be capable of perceiving its pain. A very acute pain produces either death, or fainting, which is a state similar to death; the body can suffer but to a certain degree; if the torture becomes excessive, it destroys itself; and the mind ceases to perceive, when the body can no longer endure.

In this manner excessive pain admits of no reflection; and wherever there are any signs of it, we may be sure, that the sufferings of the patient are no greater than what we ourselves may have remembered to endure.

But, in the article of death, we have many instances in which the dying person has shewn, that every reflection that presupposes an absence of great pain, and, consequently, that pang which ends life, cannot even be so great as those which have preceded. Thus, when Charles XII. was shot at the siege of Frederickshall, he was seen to clap his hand on the hilt of his sword; and although the blow was great enough to terminate one of the boldest and bravest lives in the world, yet it was not painful enough to destroy reflection. He perceived himself attacked, he reflected that he ought to defend himself, and his body obeyed the impulse of his mind, even in the last extremity. Thus, it is the prejudice of persons in health, and not the body in pain, that makes us suffer from the approach of death; we have all our lives, contracted a habit of making out excessive pleasure and pains; and nothing but repeated experience shews us, how seldom the one can be suffered, or the other enjoyed to the utmost.

If there be any thing necessary to confirm what we have said, concerning the gradual cessation of life, or the insensible approaches of our end, nothing can more effectually prove it, than the uncertainty of the signs of death. If we consult what Winslow or Bruhier have said upon this subject, we shall be convinced that between life and death, the shade is so very undistinguishable, that even all the powers of art can scarcely determine where the one ends, and the other begins. The colour of the visage, the warmth of the body, the suppleness of the joints, are but uncertain signs of life, still subsisting; while, on the contrary, the paleness of the complexion, the coldness of the body, the stiffness of the extremities, the cessation of all motion, and the total insensibility of the parts, are but uncertain marks of death begun. In the same manner, also, with regard to the pulse, and the breathing: these motions are so often kept under, that it is impossible to perceive them. By approaching a looking-glass to the mouth of the person supposed to be dead, people often expect to find whether he breathes or not. But this is a very uncertain experi-

ment. The glass is frequently sullied by the vapour of the dead man's body; and often the person is still alive, although the glass is no way tarnished. In the same manner, neither burning, nor scarifying, neither noises in the ears, nor pungent spirits applied to the nostrils, give certain signs of the discontinuance of life; and there are many instances of persons who have endured them all, and afterwards recovered, without any external assistance, to the astonishment of the spectators. How careful, therefore, should we be, before we commit those who are dearest to us to the grave, to be well assured of their departure. Experience, justice, humanity, all persuade us not to hasten the funerals of our friends, but to keep their bodies unburied until we have certain signs of their real decease.*

*The case of the Rev. William Tennent an eminent and pious Minister of the Gospel, at Freehold, New-Jersey, which is so well authenticated as to preclude the least shadow of doubt, is a striking warning, not to hasten the funerals of our friends. The account runs thus:

After a regular course of study in Theology, Mr. Tennent was preparing for his examination as a candidate for the ministry. His intense application affected his health, and brought on a pain in his breast, and a slight hectic. He soon became emaciated, and at length appeared like a skeleton. His life was now considered in danger. He was attended by a physician, a young man who was attached to him by the strictest and warmest friendship. He grew worse and worse, till little hope of life was left. In this situation his spirits failed him and he began to entertain doubts of final happiness. He was conversing one morning with his brother in latin, on the state of his soul, when he fainted and died away. After the usual time, he was laid out on a board according to the common practice, and the neighbours were invited to attend his funeral the next day. In the evening, his physician and friend returned from a ride into the country, and was afflicted beyond measure at the news of his death. He could hardly be persuaded it was certain, and on being told that one of the persons who had assisted in laying out the body, thought that he had observed a little tremor of the flesh under his left arm, although the body was cold and stiff; he endeavoured to ascertain the fact. He first put his hand into warm water to make it as sensible as possible, and then felt under the arm, and at the heart, and affirmed that he felt an unusual warmth though no one else could. He had the body restored to a warm bed and insisted that the people, who had been invited to the funeral should be requested not to attend. To this the Brother of the deceased objected, as absurd, there appearing every symptom of death, the lips discoloured, and the whole body cold and stiff. However the Doctor finally prevailed, and all probable means were used, to discover symptoms of returning life. But the third day arrived, and no hopes were entertained of success, but by the Doctor, who never left him night or day, the people were again invited to the funeral, and assembled for the purpose. The doctor still objected, and at last confined his request for delay to one hour, then to half an hour, and finally to a quarter of a hour. He had discovered that the tongue was much swoln, and threatened to crack. He was endeavouring to soften it by some emollient ointment put upon it with a feather, when the Brother came in, about the expiration of the last period, and mistaking what the doctor was doing for an attempt to feed him, manifested some resentment, and in a spirited tone, exclaimed, "it is shameful to be feeding a lifeless corpse," and

Indeed soon after the creation, when the earth was to be peopled by one man and one woman, the wise providence of God prolonged the life of man to above 900 years. After the flood, when there were three men to people the earth, their age was cut shorter. And none of these patriarchs, except Shem, attained to 500 years. In the next century, none reached 240. In the third, none but Terah lived 200: men being then so increased that they built cities and divided into different nations. As their number increased, the length of their lives diminished, till about the time of Moses it was reduced to 70 or 80 years, where it stands at this day. This is a good medium, so that the earth is neither overstocked, nor kept too thin of inhabitants. If men were now to live to Methuselah's age, of 969 years, or only to that of Abraham's, of 175, the earth would be over-peopled. If, on the contrary, the age of man was limited, like that of divers other animals, to 10, 20, or 30 years, it would not be peopled enough. But, at the present rate, the balance is nearly even, and life and death keep on an equal pace.

This is highly remarkable, that wherever any account has been taken, there is a certain rate and proportion in the propagation of mankind. Such a number marry, and so many are born, in proportion to the number of persons in every town or nation. And as to births, two things are very observable: one is, the proportion of males and females; fourteen males to thirteen females, which is exactly agreeable to all the bills of mortality. And this surplusage of males allows one man to one woman, notwithstanding the casualties to which men are exposed above women. The other is, that a few more are born than appear to die in any place. This is an admirable provision for extraordinary emergencies, to supply unhealthy places, to make up the ravages of epidemic distempers, and the depredations of war; and to afford a sufficient number for colonies, in the yet unpeopled parts of the earth. On the other hand, those extraordinary, expenses are not only a just punishment of sin, but also a wise means to keep

insisted with earnestness, that the funeral should immediately proceed. At this critical and important moment, the body, to the great alarm and astonishment of all present, opened its eyes, gave a dreadful groan, and sunk again into apparent death, this put an end to all thoughts of burying him, and every effort was employed, in hopes of bringing about a speedy resuscitation. In about an hour the eyes again opened, a heavy groan proceeded from the body, and again all appearance of animation vanished. In another hour, life seemed to return with more power, and a complete revival took place, to the great joy of the family and friends, and to the no small astonishment and conviction of very many, who had been ridiculing the idea of restoring life to a dead body.

In another instance, we read an account of a person being conveyed away in his coffin to the grave, where a noise was heard as if struggling, which evidently proceeding from the coffin, it was opened, and the body was found alive.

the balance of mankind even. So one would be ready to conclude, by considering the Asiatic, and other more fertile countries, where prodigious multitudes are swept away by wars and plagues, and still they remain full of people.

As to the length of life, it has been an ancient opinion, that men lived longer in cold countries than in hot. But the reverse is true. The inhabitants of the Caribbee islands frequently live a hundred and fifty years. In the Molucca islands, the ordinary life of the natives is a hundred and thirty years. In Sumatra, Java, and the neighbouring islands, the life of the inhabitants commonly extends to a hundred and forty years: in the realm of Cassuby, to one hundred and fifty. The Brasilians frequently live one hundred and sixty years, and many, in Florida and Jucatan, still longer.

Nor is this at all improbable. For there being no such inequality of weather in those climates as in ours, the body is not shocked by sudden changes, but kept in a more equal temper. And sickly persons with us, when fixt to their beds, and kept in an equal degree of heat, are often found to hold out many years, who would otherwise scarce have survived one.

Before concluding this head, we may observe one more eminent instance of the divine Wisdom, in the great variety throughout the world of men's faces, voices, and hand-writing. Had men's faces been cast in the same mould, their organs of speech given the same sound; and had the same structure of muscles and nerves, given the hand the same direction in writing; what confusion, what numberless inconveniencies must we have been exposed to? No security could have been to our persons, no certainty of our possessions. Our courts of justice abundantly testify the effects of mistaking men's faces or hand-writing. But this, the wise Creator has taken care to prevent from being a general case. A man's face distinguishes him in the light, as his voice does in the dark: and his hand-writing can speak for him when absent, and secure his contracts to future generations.

Lastly, how admirably has God secured the execution of his original sentence, upon every child of man, "dust thou art, and unto dust shalt thou return!" From the moment we live, we prepare for death, by the adhesion of dust, mixt with all our aliments, to our native dust; so that whatever we eat or drink, to prolong life, must sap the foundation of it. Thus, in spite of all the wisdom of man, and all the precautions which can be used, every morsel we take, poisons while it feeds, and brings us nearer to the dust from whence we came.

CHAPTER IV.

OF THE SOUL, AND OF THE ORIGIN OF MAN.

1. EVERY one finds there is something in himself which perceives the motions raised in his body by outward objects. For when we see, hear, taste, smell or feel, while the objects affect our bodily organs, we find also various perceptions in our mind, according to the variety of those objects.

2. We observe, likewise, that after the objects are removed, those perceptions often continue, yea, and are variously mixed and compounded together, which we term IMAGINATION. And a long time after, when those objects are not only removed, but even cease to exist, those perceptions return into our mind. And this we call MEMORY.

3. And as we perceive these outward objects, so we know that we do perceive them. The mind can look inward upon itself, and reflect upon its own perceptions. Over and above this we seem to find in ourselves, a knowledge of things abstracted from matter. But the more we labour to penetrate into the nature of this divine principle, the more it seems to retire and withdraw itself from our most studious researches.

4. In like manner we find in ourselves various appetites for good things, and aversions to evil things: yea, the very involuntary motions of the body tend to avoid the evil and attain the good. And the things which are perceived by our senses, or represented by our imagination, so necessarily affect us, that we can by no means hinder ourselves from having an appetite for some, and an aversion to others.

5. Yet frequently, a more hidden and sublime appetite exerts itself in our minds: one that checks, controls, and exercises authority over all the rest. For if we are convinced, that the things which are pleasant, are nevertheless hurtful, the appetite for them is overruled, and we find a desire, not to enjoy, but to avoid them.

6. In order to explain these things, philosophic men suppose, that all the involuntary motions, of the body, are performed in a mechanical manner, by matter so and so modified: and that such effects spring of course from such causes, according to the stated laws of motion.

7. As to the SENSES, they suppose, that when the organs of sense are struck by any of the bodies that surround us, and the motion caused thereby continued through the nerves to the brain, the soul,

residing there, is suitably affected: God having so closely connected the soul and the body, that on certain motions of the body, if conveyed to the brain by means of the nerves, certain perceptions of the mind always follow: as, on the other hand, on certain perceptions of the mind, certain bodily motions follow.

8. They suppose, if these motions, which are by the nerves communicated to the brain, continue there after the objects are removed, the perception of these is IMAGINATION: which, if it occurs after it has ceased, is then styled MEMORY. Others suppose, that imagination results from the motion of the animal spirits, through those traces which were made in the brain, while the outward objects were present; and memory, from the spirits moving through them afresh, after some intermission.

9. Once more. They suppose there are two faculties in the soul; one that is passive, the UNDERSTANDING, by which it perceives all the motions of the body, and knows and reflects on its own operations: the other active, the WILL, by which we incline to good and are averse to evil. The AFFECTIONS are only, the will exerting itself variously on various objects.

10. To speak freely upon the matter. I know the body of man is contrived with such exquisite wisdom, that he is able, by means of the organs of sense, to perceive outward objects: to continue those perceptions, to recall them after they are gone, and by a reflex act, to know what passes in his mind or body. But I know not how to account for any of these things.

11. That the SOUL is immaterial, is clear from hence, that it is a thinking substance. If it be said, "God can endue matter with a faculty of thinking:" we answer, no otherwise than he can endue a spirit with solidity and extension; that is, he can change spirit into matter: and he can change matter into spirit. But even the Almighty cannot make it think while it remains matter; because this implies a contradiction.

12. The UNION of the soul and body is another of those things which human understanding cannot comprehend. That body and spirit cannot be implicated or twisted together like two bodily substances, we know. But how two substances of so widely different natures, can be joined at all, we know not. All we can tell is this: God has ordered that certain perceptions in the soul should constantly follow certain motions of the body, and certain motions of the body such perceptions in the soul.

13. How mankind began, is another point, which is too hard for our reason to determine. That men always existed, is no way probable, were it only on this account, the late invention of arts. For since it appears, at what time the most necessary arts were invented,

we cannot reasonably suppose, than men began to exist long before that period: seeing, if they had always existed, no reason can be given, why these, and many more arts, were not invented long before. And yet the accounts given of the origin of mankind, by the wisest of the heathen philosophers, are so above measure ridiculous, that they serve as a melancholy proof of the weakness of barely natural reason.

14. The scriptural account is this: God made the body of man out of the earth, and breathed into him the breath of life; not only an animal life, but a spiritual principle, created to live for ever. Even his body was then perfect in its kind; neither liable to death nor pain. But what the difference was, between the original and the present body, we cannot determine.

But, to form it even as it is now, no less than a Divine power was requisite. No less could mix the primary elements, in so exact a proportion, and then frame so many different parts, of so various figure, texture and magnitude. God alone was able to form the original fibres; to weave those fibres into hollow tubes; to dispose these tubes, filled with their several humours and variously interwoven with each other, into different organs: and of those organs connected together in a continued series and due situation, to finish so complicated and wonderful a machine as the human body.

15. Nothing was wanting now, but that the immortal spirit should be sent into its habitation, to bear the image of its Creator and enjoy his glory. But the manner wherein this was done we cannot tell: this knowledge is too wonderful for us. And it is of no use to indulge mere conjecture, where knowledge is unattainable.

Even the present production of the body by generation is what no man can fully explain. But this we know: the female OVARIES, which hang on each side of the womb, contain abundance of small vesicles, filled with a transparent liquor. Some suppose, that each of these contains, in miniature, all the parts of a human body: that when one of them is penetrated by the male seed, it is rarified and expanded thereby, till it breaks the membranous shell, and by the fallopian tube, falls down into the womb. Here, being lightly fastened to the sides of the womb, it receives nourishment from the mother, till the heart is formed and begins to propel the blood to the extremities of the still increasing body. When it is come to its full size, by rolling to and fro, it tears asunder the enclosing membranes, and having burst as it were the prison-bars, emerges into light.

The first thing that appears of a fœtus is the PLACENTA, like a little cloud on one side of the outer coat of the egg. About the same time, the spine becomes visible; and a little after, the brain and cerebellum appear like two small bladders. Next the eyes stand prominent in

the head: then the punctium saliens, the heart-beating is plainly to be seen; and last of all the extremities. When formed, the fœtus lying in the womb, is almost of an oval figure. For the head hangs down with the chin upon the breast. Its back is round. With its arms it embraces the knees, which are drawn up to the belly, and its heels are close to the buttocks. Its head is upward, and its face to the mother's belly. About the ninth month, the head, which till then was lighter, becomes heavier than any other part. In consequence of this, the head falls down in the liquor that contains it; the feet get loose, and the face turns toward the mother's back. But being now in an uneasy posture, it struggles and brings on the mother's throes.

Mr. Dodart, nicely observing an embryo, one and twenty days old, found the placenta more than half of the whole; and thence concludes the younger the embryo is, the larger is the placenta in proportion to it: a plain reason, why miscarriages, though the fœtus is less, are more dangerous than regular deliveries. For though the embryo in a miscarriage makes a way sufficient for itself, it does not make a way for so large a placenta as is to follow it.

The embryo itself was only seven lines long, from the top of the head to the bottom of the spine, where it terminated. The thighs were not unfolded; they only appeared like two little warts at the bottom of the trunk. The arms made the same appearance on the shoulders. The head was one third of the whole length. On this were two small black points, which would have been eyes. The mouth was very big; a plain indication that it fed thereby. There was no eminence for the nose; but two little, almost imperceptible pits for the nostrils. Always the younger the embryo, the bigger the head is, in proportion to the body. The parts nearer the head are likewise bigger, in proportion to the rest.

It weighed less than seven grains, which is an extraordinary lightness, for a body seven lines long. It was so soft, that no part of it could be touched, without making a change in its figure. Upon opening it, Mr. Dodart discovered the heart and the right auricle. All the other parts in the thorax and the lower belly, were simple outlines, all vesicular, except a part on the left side, probably the spleen.

Some suppose, that millions of animalcula swim in the seed of male animals, which are so many embryos, for which a receptacle only is provided in the eggs of the female. But all agree, that either the male seed, or the female egg, contains all the parts of the body; so that generation is no more than the growth or unfolding of the parts there delineated. But how these seeds, whether male or female, are elaborated and prepared, abundantly transcends the highest reach of human understanding.

If the animalcula, of which all animals are formed, are originally in the male, yet they never can be formed into animals, without the egg of the female.

That all animals spring from animalcula, seems probable from the following considerations:

1. That something may be observed in the *tread* of an egg, even before incubation, like the rudiments of an animal, in form of a tadpole.

2. That after incubation, all the parts of the animal suddenly appear, the *stamina*, which existed before, being then expanded. After three days incubation, the punctum saliens of a chick is discovered by the naked eye. On the fifth day, the rudiments of the head and body appear, which were before discernible by glasses. After thirty hours, we see the head, the eyes, the heart, and the carina, with the vertebræ distinct. And by glasses we see all those parts, after forty hours, which the naked eye cannot discern till the fifth day. Whence it is probable, that even the first discovery of them by the microscope, is not the discovery of the parts newly formed, but of those that existed before incubation, though not then dilated enough to be visible.

3. That there is a near analogy between animals and plants. Now we know, the seeds of these are only little plants, folded up in membranes. Hence we may easily infer, that animals proceed from animalcula folded up, till they are gradually enlarged and unfolded.

And that these animalcula are originally in the seed of the male, is probable. For, 1. Numberless animalcula are observed in the seed of animals. 2. We observe the rudiments of a fœtus in eggs fecundated by the male, but not in others. 3. The rudiments in the egg, both before and after incubation, exactly resemble the animalcula in the seed. 4. This gives a rational account of many fœtuses at one birth, especially that of the countess of Holland. It accounts also for a whole cluster of eggs in a hen, being fecundated at once. 5. This best suits the analogy between animals and plants. Every herb and tree bears its own seed, and a little plant of the same kind, which being thrown into the womb of the earth, spreads forth its root and receives its nourishment from the earth, but has its form within itself.

Yet, that no animal can be formed without the egg of the female, is evinced by the following considerations:

1. No animalcula can come forward, if it do not fall into a proper nidus. So though a thousand should fall into one egg, none of them would come forward, but that which was in the very centre of the cicatricula, or thread. And perhaps the nidus necessary for their formation is so proportioned to their bulk, that it can hardly contain more than one animalcula. This is certainly the case in oviparous

kinds. And all the difference between the viviparous and the oviparous is, that in the former, the egg is nothing but the cicatricula with its yolk: so that the fœtus must draw its nourishment from the womb. Whereas, in the oviparous, the egg itself is a kind of womb, containing all that is needful for the animal, till it is hatched.

2. It is acknowledged, that the fœtus in the womb, is not connected with it, for a considerable time after conception: that it is wholly loose from it, and is only a little round egg, with the embryo in the midst, which sends forth its umbilical vessels by degrees, and at last lays hold on the womb. Hence it is plain, that the cicatricula, which nourishes the animalcula, does not spring from the womb, but only falls into it, as a fit soil, whence it may draw nourishment, for the fœtus.

Yet there is a difficulty which presses equally on those, who suppose the animal to spring either from the male or female parent. It is the case of monsters. In a mule, for instance: the body is of the form of a mare: whereas the feet, the tail and the ears, resemble those of its sire. If the male supplied the animalcula, one would imagine the fœtus should always be of the same species with the male. If the female, it should be of her kind: whereas monsters are of both: as if the main part of the animal lay in the egg, and the impregnation only conveyed or changed the extremities.

Yet that some animals first exist, not in the seed of the male, but wholly in the egg of the female, undeniably appears from the case of frogs and toads. And why may it not be the same thing with other animals? The eggs of those are not impregnated by the male, till they issue from the womb. It is while they are ejected, that he fecundates them with his seminal liquor. And there is no circumstance, by which the fecundated egg can be known from the unfecundated. It appears, therefore, that tadpoles exist before fecundation. For the unfecundated eggs do not differ in the least from those that are fecundated. But these are only tadpoles coiled up. Such, therefore, are the unfecundated tadpoles: they exist before fecundation: only they cannot unfold themselves without the liquid of the male. Frogs then should not be placed among oviparous animals, but among viviparous: if they do not rather constitute a class between both. Thus nature seems to delight in diversifying the modes of animal generation.

This may be the case with regard to one or perhaps a few species of animals. But in general, where to place the pre-existent animal or embryo, in the animalcula or the egg, is still the question. A division of vital, essential, and original stamina, is impossible. Yet innumerable instances in monsters, mules, and many natural subjects, concur to prove, that the young partakes of the nature and qualities of both

the parents, even to their defects and diseases, which are often hereditary. How then can we suppose unalterable stamina? Can the visible species of any production be determined by them, if every sensible quality may be influenced indiscriminately by either parent.

If they are placed in the animalcula or the egg, how are they transmitted? If in the animalcula, why is the process attended with so vast an expense, so great a waste of millions of entities, each containing a series of the most perfect, and most wonderful productions, when one only of those millions is to take place? And how are these animals generated? If in the common way, not only the process will be boundless, these in their seed will have others, and so on in an endless series; but they cannot then be unalterable, because they are capable of being generated. Further, if they float in the air, or lie hid in food, how is it that the stamina of one species does not sometimes insinuate themselves into a parent of another species? Or if they are excluded, by proper strainers, in distant species, they cannot be so in those that are near akin. For if the spermatic animal, which in the matrix of a mare, produces a horse, is yet so fitted to that of an ass, that it can possess a cellude there, exclusive of every other, which shews an exact co-aptitude; certainly the same animal, if contained in food or air, common to both horse and ass, might pass indiscriminately the strainers of either: and so we might have mules without the promiscuous congress of the two species.

In another view, if we consider the extreme tenuity of one of these stamina, in its first origin at the distance of many ages, compared to the smallest fibre of the animal it is said to constitute: can so minute a filament serve as a substratum for a cylinder, comparatively immense? Can the terraqueous globe derive its present dimensions, from the dilatation of an atom? Such is a muscular fibre in its present state, compared to what it was in its origin. Consequently, what must have been the increase of extraneous matter, either by apposition or incorporation, which is now as much a part of the fibre, as the original stamen? And if thus much can be mechanically assimilated, why not the whole formed by mechanical causes? or why must so insignificant a part of it, be supposed to be concreted with the universe?

The difficulty still increases immensely, if we look into the vegetation of plants and the wonderful re-prodution of the parts of the polypus, lobsters, and many other animals. The original stamina, how minute soever, questionless, are diffused through the whole production: since in this system all animal and vegetable growth is made by developement only. But if diffused, then some or all may be lost by successive bisection. And if lost, how can they be re-produced? if re-produced, how were they concreted with the universe? These

and a thousand other difficulties can in no wise be evaded, but by multiplying supposition on supposition, which renders the hypothesis so complex, as utterly contradicts the ordinary process of nature.

It is more reasonable to say, that so many secretory ducts, so many strainers, so many preparatory vessels in animals, and such a curious disposition in plants for the continuation of every species, imply a digestion, secretion, and preparation of principles, invariably productive of every individual, when they fall into their respective matrixes, and find aliment proper to assimilate. Are not these principles contained in nourishment taken by the parent plant or animal, the same that continually vegetate in it, and increase it till it is adult, then exuberate, while it is by new preparations fitted, invariably to propagate its kind? else why this digestion? why this secretion? why so many strainers, receivers, ducts and valves? and why is some food more productive of these principles than others?

And if every mixt body is made up by the combination of certain principles, we cannot doubt but God may have established forces in nature, by which such principles may, in certain circumstances, be invariably united, without any danger of deviating so as to render generation equivocal. And if every production in question is a mixt body, we know that how various soever they are, a small number of principles differently combined will yield variety enough to produce them all. Thus we reduce nature to what it is ever found to be, simple in the beginning of its course, but afterwards, when it is distributed, magnificent beyond expression.

Modern naturalists all agree, that every plant proceeds from its specific seed; every animal from an egg, or something analogous, pre-existing in its parent. But what do we mean by seeds and eggs? these in the common sense of the words, are certain mixt bodies, that immediately furnish those productions. They are said to contain not only the pre-existent germ, but the fit nidus also, and aliment to be assimilated in proper circumstances. They are therefore heterogeneous bodies that coalesce in a known time. And their principles are so far from being united at the creation, that they sensibly come together from distant places, in all hermaphrodite plants, and from different individuals in all those species, where the male and female are distinct.

But it is vain for us to lay down any certain rule, and to say to nature, "this is thy scheme; from this thou shalt not deviate." If she makes it a law in many species, that every individual requires the co-operation of a male and female parent; she has, at the same time, her hermaphrodites, both in plants and animals. And if in some hermaphrodites, the sexes are so distinct, that she seems not to deviate far from her primitive law; she will in another instance, that of

the pucerons, act either with or without the co-operation of a male. Again: in some species, the female may be so impregnated, that the impregnation shall diffuse itself to five or six generations. Yet again: in many kinds of polypus, generation proceeds without male or female, egg, or seed. And farther still; there are some species of polypus, where a whole family, after branching out by real vegetation, as far as nature designs, jointly concur to furnish one egg, as the source of a future progeny. If at last you resolve to stand by this, that at least every individual proceeds from a parent like itself; even this is overthrown by late experiments. For we have now a cloud of instances, of a class of beings hitherto unknown, wherein animals grow upon, are produced by, and in the strictest sense of the word, brought forth from plants. Then, by a strange vicissitude, they become plants of another kind. These again become animals of another, and thus on, for a series farther than the utmost power of glasses can carry the most inquisitive observer.

And as to the animalcula supposed to be discovered in the male seed, the microscope discovers the same in the seminal liquor of females. Probably neither the one, nor the other are real animals, but only inanimate particles in strong fermentation.

PART THE SECOND.

OF BRUTES.

CHAPTER I.

OF BEASTS.

1. NEXT to man in the visible creation are BEASTS. And certainly, with regard to the structure of the body, the difference is not extremely great, between man and other animals. Only in this, that the structure of man is erect, and his form more elegant; that no beast has the feet of a man, much less the hand so admirably fitted for every purpose: and lastly, that no other animal has a brain, so large in proportion to its bulk as man. Concerning the prone posture of their body we may observe two things; the parts ministering thereto, and the use thereof.

1. As to the parts, it is observable, that in all these creatures, the legs are made exactly conformable to their posture, as those of man are to his posture: and farther, that the legs and feet are always admirably suited to the motion and exercise of each animal. In some they are made for strength, to support a vast unwieldly body: as in the elephant, which being a creature of such prodigious weight, has its legs accordingly made like pillars. In others, they are made for agility and swiftness. So deers, hares, and several other creatures, have their legs very slender, but strong withal, and every way adapted for quick motion. In some, they are formed only for walking and running; in others, for swimming too. Thus in the feet of the otter, the toes are all conjoined with membranes, as they are in geese and ducks. And in swimming it is observable, that when the foot goes forward in the water, the toes are close; but when backward they are spread out: whereby they more forcibly strike the water, and drive themselves forward. In others, as moles, they are made for walking and digging: and in others, for walking and flying.* In some they are made more weak, for the plainer lands; in other, stiff and less flexible,† for traversing ice and dangerous precipices. In some

* The membranous wings of a bat are a prodigious deviation from nature's ordinary way. And so is the Virginia flying squirrel; whose skin is extended, in the nature of wings, between its fore-legs and body.

† The elk has legs so stiff and inflexible, that they run on ice without slipping. And this is the way they take, in winter, to save themselves from the wolves.

they are shod with rough and hard hoofs, in others with only a callous skin.* In the latter, the feet are composed of toes: some short, barely for going; some long, to supply the place of a hand: some armed with long and strong talons, to catch, hold and tear the prey; and some fenced only with short nails, to confirm the steps in running and walking.

II. 1. As the posture of man's body is the fittest for a rational animal, so is the prone posture of beasts, the most useful to themselves, and the most fit for the service they perform to man.

2. But this is a wonderful agreement between the bodies of men and beasts, not only with regard to the structure, but also the use of the several parts. How they differ, will be mentioned hereafter.

3. The BRAIN in them is of nearly the same structure and consistence as in man, and undoubtedly performs the same office, secreting the animal spirits (if such there be) in order to sensation and muscular motion in every part of the body. The *cerebellum* is nearly of the same shape in all. But the shape of the brain necessarily varies according to that of the head.

It is remarkable, that in man the head is of one single form: whereas in the four-footed race it is as various as their species. It is, in some, square and large, suitable to their food, abode, and slow motion: in others, it is small, slender and sharp, agreeable to their swifter motion, or to make way to their food, or habitation under ground. And as to the brain contained therein, how small is it in beasts, in proportion to what it is in man! Another thing no less remarkable is the situation of the brain and the cerebellum. As God has given to man a lofty countenance, and has lodged in his brain an immortal soul, to behold and contemplate heavenly things, so as his face is erect, his brain is set in a higher place, above the cerebellum and all the sensories. But in brutes whose face is prone to the earth, and who are not capable of speculation, the cerebellum, which ministers merely to animal life, is placed above the brain. Also some of the organs of sense, are placed, if not above the brain, at least on a level therewith.

Another very great convenience in this position of the brain and cerebellum is, in the head of man, the base of the brain and cerebellum, yea of the whole skull, is set parallel to the horizon; by which means there is the less danger of the two brains joggling or slipping out of the place. But in the beasts, whose heads hang down, the base of the skull makes a right angle with the horizon. By which

* The goat, which generally dwells on mountains and rocks, and delights to walk on narrow ridges, and to take great and seemingly dangerous leaps, has the joints of the legs remarkably stiff and strong. Likewise the hoof is hollow underneath, and its edges sharp.

means the brain is beneath, and the cerebellum above. And lest the cerebellum should hereby be liable to frequent concussions, an admirable provision is made, by that strong membrane, the *dura mater*, closely encompassing it. Beside this, it is guarded in some species with a strong bony fence. In the hare, the coney, and several others, a part of the cerebellum is on each side within the *os petrosum*. So that its whole mass is, by this double stay, firmly contained within the skull.

4. The heart and lungs in beasts are of the same structure, with the same apparatus of veins and arteries, as in men. We cannot therefore doubt but the blood circulates in them, and nutrition is performed as in us. Their food also being dissolved in the stomach, is conveyed by the lacteals to the receptacle of the chyle. To the fore-part of this, (in men the upper part) joins the thoracic duct, which extending through the length of the thorax, ends in the vein, called, in beasts, *cruralis anterior*. The remaining part of the circulation is performed in them, as in men.

But some beasts have more stomachs than one. And some have the peculiar property of chewing the cud. The food, after it has been swallowed, is returned to the mouth, where it is chewed over again at leisure.

Not that this is altogether peculiar to beasts. There have been instances of men who had this property. Dr. Slare gives us a particular account of one whom he knew at Bristol. "He begins," says he, "to chew his meat over again, within a quarter of an hour after meals. This chewing, after a full meal, lasts an hour and a half. If he goes to bed soon after a meal, he cannot sleep, till the usual time of chewing be over. The victuals returned, taste more pleasantly than they did at first. Bread, flesh, cheese and drink, are of much such a colour, as they would be, if mixt together in a mortar. His victuals lie heavy on his stomach, till they have passed this second chewing. He was thus ever since he can remember. His father does the same, but in small quantities." What a mercy is it, that we have not more such instances! For how much of our precious time would it consume!

5. The situation, number, and conformation of the EYES in various animals, is wonderfully adapted to their various circumstances. In several, the eye looks chiefly forward, but so as to take in nearly the hemisphere before it. In others, the eyes are so placed, as to take in nearly a whole sphere. In some, they are so fixt as to look chiefly behind, so that they see their enemy following them. So in rabbits and hares: whereas in dogs they are more forward, to look after their prey.

Generally the head is moveable for the sake of the eyes, and the eyes themselves moveable every way. Where it is not so, other expedients are found, to answer the same end. Thus in some creatures, the eyes are set at a distance from the head, to be moved this way or that: as in snails, whose eyes are fixed to the end of their horns, or rather of the optic nerves which are sheathed therein. In other creatures, whose heads and eyes are immoveable this is made up by the number of eyes. So spiders, which cannot move their head, have four, six, or eight eyes, all placed in the front of the head, which is round, like a locket of diamonds.

Many animals have muscles to move the eye, and obvert it to the object. Fishes have none; but for amends, they have many little protuberances finely ranged on their large, bulging eyes: by which numberless rays of light are deflected from objects above, beneath, and on either side. Yea, some hundreds of these protuberances are curiously ranged on the convex eye of a flesh-fly.

Scorpions have above a hundred eyes; an ephemeron-fly full two thousand.

In other creatures, which have only two eyes, the want of motion therein is supplied, by their eyes protuberating into hemispheres, each being a vast number of segments of a sphere.

The eyes of a cameleon resemble a convex glass set in a round socket, which he turns backward and forward without stirring the head, and commonly one a contrary way to the other.

Lastly, moles living under ground, have not so much need of eyes as other creatures. Yet they have eyes, but exceedingly small, far in the head, and covered with strong hair. When they are above ground, they can put them forth beyond the skin, and draw them back at pleasure.

Another circumstance, relative to the eye, is highly remarkable. As we use various apertures to our optic glasses, so nature has made a far more complete provision, to admit enough, and not too much light, into the eyes of animals, by the dilatation and contraction of the pupil. And this, in divers animals of divers forms, is according to their peculiar occasions. In some it is round, particularly in man. That being the most proper figure for the position of our eyes, and the use we make of them, both by day and night. In some animals it is of a longish form, in some transverse, with its aperture large (an admirable provision for their seeing sideways,) and thereby avoiding many inconveniences, as well as a help for gathering their food on the ground, whether by day or night. In others, that aperture is erect, and also capable of opening wide and shutting close. The latter serves to exclude the bright light of the day, the former to take in

the faint rays of the night: thereby enabling them to see and catch their prey, when there is no light discernible to us.

Thus cats can so close their pupil, as to admit but a single ray of light. And again, by throwing all open, they can take in all the faintest rays: which is an incomparable provision for creatures that have occasion to watch their prey both by day and night.

But beside this, in cats and other nocturnal animals, there is a sort of carpet at the bottom of the eye, which gives a kind of radiation on the pupil, thereby enabling them to see in the dark.

To preserve this tender organ, many creatures have a membrane, which is not commonly perceived, wherewith they can at pleasure cover the eye, without too much hindering the sight; being both transparent and strong, so that it is a kind of moveable cornea.

Providence is conspicuous in furnishing frogs with this. For as they live in watery places, which generally abound in plants that have sharp edges or points; and as the frog goes on, not by walking but by leaping, if he were not so furnished, he must either shut his eyes, and so leap blindfold, or run many risks by leaving them open. But this membrane guards the eyes, without blinding him. And as soon as the occasion for it is over, he draws it back into a little cell. Many birds also, as they must fly between trees and bushes, are provided with the same membrane. And so is the rein-deer.

6. The comparative anatomy of the EAR, yields abundant instances of the Creator's wisdom. In birds the outward ear is close and covered, not protuberant; as that would obstruct their flight. In beasts, its form is agreeable to the posture and motion of the body, but admirably varied in the several species, according to their various occasions. In some, as the hare, it is large, open and erect; by which means that timorous, helpless creature, is warned of the least approach of danger. In others, it is covered to keep out noxious bodies. In those which are forced to mine and dig for their habitation, it is short, and lodged deep and backward in the head. Thus moles have no auricle at all; but only a round hole, between the neck and shoulder. And this is closed with a little skin, which opens and shuts like an eye-lid. The sea-calf also, as well as lizards and serpents, have no outward ear. And the tortoise, with most kinds of fishes, have the passage quite covered over.

But among all the varieties in the structure of this organ, none are more remarkable than those of the passage into the *os petrosum*. In an owl, which perches upon a tree or beam, and hearkens after the prey beneath her, it comes farther out above than below, for the better reception of sounds from beneath. In a fox, which scouts under the prey at roost, it comes farther out below than above. In a pole-cat, which hearkens strait forward, it is produced behind, for

the taking a forward sound. Whereas a hare, whose enemy comes behind, is supplied with a bony circle, directed backward: by means of which she receives distinctly the smallest sound which comes that way.

The more accurate the sense of smelling is in any creature, the longer are the laminæ in the nostrils, and the more in number, folded up, and crowded together, to contain more nervous filaments, and to detain the odoriferous particles, in their windings and turnings. An admirable provision this, for the good of many creatures, the chief acts of whose lives are performed by the ministry of this sense In insects and many other creatures it is of great use, in helping them to proper places for hatching their eggs, and breeding up their young. And most irrational animals, beasts, birds and reptiles, do by their smell find out their food. With what sagacity do some of them discover it, in the midst of mud and dirt! How curiously do others pick and choose such plants as afford them wholesome food, perhaps medicine too, avoiding such as tend to hurt or destroy them! And all this principally by the smell, together, with its near ally, the taste.

The various forms of the TEETH in various creatures, is another instance of the Divine Wisdom. How curiously are they adapted to the peculiar food and occasion of each species! Thus in the rapacious, they are fitted to catch and hold their prey; in the herbaceous, to gather and chew vegetables. In those which have no teeth, as birds, the bill supplies that defect; together with their additional stomach. And it is a remark which hardly fails: all such animals as have four stomachs, have no teeth at all.

There are great varieties in the teeth of other animals. Trout have teeth upon their tongues; cod-fish at the bottom of their gullet. Crocodiles have three rows of teeth on the same jaw; sharks, four or five; sea-devils, so called, have several rows of moveable teeth.

7. The variation of the WIND-PIPE, in various creatures, is likewise observable, as it is necessary for that of the voice. In a hedgehog, which has a very small voice, it is hardly more than membranous. In a pigeon, which has a low, soft note, it is partly membranous, partly cartilaginous. In an owl, which has a good audible note, it is more cartilaginous. But that of a jay, or of a linnet, has bones instead of cartilages.

The rings of the wind-pipe likewise are fitted for the modulation of the voice. For in dogs and cats, which use a great many notes, they are as in man, open and flexible: whereby all or any of them is more or less dilated or contracted, in order to a deeper or shriller note. But they are one entire ring in the Japan peacock, which uses one single note.

8. As to the motions of brutes, it is not easy to conceive, that even those of the vegetative kind, can be the mere mechanical effects of matter, however modified. Much less can we conceive this of their sensitive motion: for we have not the least reason to doubt, but the same impressions of external objects, raise the same perceptions in them as in us. No question, they see and hear, and smell, and taste, and feel in the same manner as men!

9. We cannot therefore deny that there is something in brutes, which perceives the impressions made by outward objects; and that they perform a thousand actions, which can never be explained by mere mechanism: those in particular which spring from what we call instinct, as the feeding and tending their young, the building their nests and preparing their habitation, upon or in the earth.

It is true, some things in brutes, as well as in men, may be mechanically accounted for. But others cannot: so that we are constrained to own, there is in them also some superior principle, of whatever kind it be, which is endued with sense, perception and various appetites. For from their outward actions we may as easily learn, as we could from those of a man born deaf and dumb, that there are in this principle or soul* two different faculties: that of perceiving or knowing, answerable to our understanding: and that of desiring and shunning, answerable to our will. That this principle is immaterial

*Much speculation and reasoning have been indulged on the proposition, whether brutes have a soul or not. Many curious, entertaining, and even elaborate essays, have been made on this subject: but it would seem as if it was not difficult to come at a decision, at once concise and satisfactory. The sacred volume informs us, that God made all things by the word of his power: and that without him, nothing is, that is. That in him we live, and move, and have our being. That with him is neither variableness, nor shadow of turning: and that he is the same yesterday, to-day, and so for evermore. Hence we are taught that God is the inexhaustible and immutable source, whence all things proceed: that when the body returns to dust, the spirit returns to God who gave it. Agreeably to that beautiful allusion in Scripture.—Earth to earth.—Ashes to ashes.—Dust to dust. And might not the expression consistently imply, spirit to spirit, intellect to intellect, species to species. Hence we should infer, that God is the great first cause of all things, and that all creatures are the effect of that cause. And while we query the immortality of the effect, the immortality of the cause will remain unquestioned. Nor will it be questioned that an immortal cause can produce a mortal effect. Or that this state of being, is a state of mortality alike to brutes and men. Hence the true expression of the proposition will be: that man is endued with an immortal rational soul. And the utmost query will be, whether brutes are endued with an immortal sensitive soul, for they cannot be regarded as moral and responsible agents. No question! The brute returns to its immortal, original, elementary essence. And man as a moral, and responsible being, returns to give an account of the deeds done in the body; and even of his benevolence to the brutes: for it is a command to be merciful to the brutes. But man! proud man! high and lifted up in the scale of being,—proceeding from the

appears from this single consideration, it has a power of self-motion; which no matter can have, being wholly and essentially passive.

10. It is not my design to enumerate the several species of beasts. But it may illustrate the wisdom of the great Creator, to give some account of a few; several of which are not so commonly known.

The largest land-animal in the world is an ELEPHANT, which seems rather to belong to the hog-kind than any other. They are found only in the south of Africa, and in the East-Indies, and are generally of a dark colour. Their eyes are like those of a hog. At the corners of their mouth grow two large teeth, six or seven feet long in the male, but not above one in the female. They feed on grass, nuts, and other vegetables.

Of all quadrupeds, the elephant is the strongest as well as the largest; and yet in a state of nature, it is neither fierce nor formidable. Mild, peaceful and brave; it never abuses its strength, and only uses it for its own protection. In its native deserts, the elephant is a social friendly creature. The oldest of the company conducts the band; that which is next in seniority brings up the rear. The young, the

same common parent, forgets, or surveys at a distance his near kindred, the brute, and the worm. And instead of the merciful proprietor, the victim of depravity himself, he becomes the capricious despot, and the inflexible tyrant: lording it over the whole creation with rapacious wantonness, and relentless cruelty.

But the same reasoning will apply to all things, even the meanest, and apparently the most insignificant of created beings. For not a poor chattering sparrow, nor even a hair of your head, shall fall to the ground without your heavenly Father's notice. Which expression is undoubtedly intended to teach us, that every particle of matter in the whole universal range of existence, is accountable, and returnable to its original essence, and that it cannot be annihilated and lost, and here I cannot dissuade myself from quoting an expression, from a manuscript copy which I wrote some years ago on this interesting subject. Speaking of the immortal, essential principle, or soul, it proceeds,

Apply thine art with more than chemic skill,
Tear her in piece-meal, burn, destroy, and kill,
Bear her where vengeance' self, with fate conspires,
And waste her bodies in an hundred fires.
Let the destroying elements engage,
And burn with more than fierce volcanic rage,
And tho' to winds, and waves in fritters tost:
Yet not a single atom can be lost.

Tho' swept where hurricane tremendous flies:
Or torn by whirlwinds dreadful to the skies.
By earthquake swallowed, or by tempest hurl'd,
To the most dreary caverns of the world.
Tho' buried at the centre, from the skies;
And crushed by falling mountains where she lies.
She wins her subtle way through every pore:
And not a thousand worlds could crush her more

weak, and the sickly, fall into the centre; while the females carry their young. They maintain this order only in dangerous marches, or when they desire to feed in cultivated ground; they move with less precaution in the forests, and solitudes: but without ever moving far asunder.

Nothing can be more formidable than a drove of elephants, as they appear at a distance, in an African landscape: wherever they march, the forest seems to fall before them; in their passage they bear down the branches, on which they feed; and if they enter into an enclosure, they destroy all the labours of the husbandman in a very shor time. Their invasions are the more disagreeable, because there is no means of repelling them; since it would require a small army to attack the whole drove when united. It now and then happens, that one or two is found lingering behind the rest, and it is against these that the art and force of the hunters are united; but an attempt to molest the whole body, would certainly prove fatal. They go forward directly against him who offers the insult, strike him with their tusk, seize him with their trunks, fling him into the air, and then trample him to pieces under their feet. But they are thus dreadful only when they are offended, and do no manner of personal injury when suffered to feed without interruption.

The elephant has very small eyes, when compared to the enormous bulk of its body. But, though their minuteness may at first sight appear deformed, yet, when we come to examine them, they are seen to exhibit a variety of expression. It turns them with attention and friendship to its master; it seems to reflect and deliberate; and as its passions slowly succeed each other, their various workings are distinctly seen. It is remarkable for the excellence of its hearing. Its ears are extremely large. They are usually dependent; but it can readily raise and move them. They serve also to wipe its eyes, and to protect them against the dust and flies. It appears delighted with music, and readily learns to beat time, to move in measure, and even to join its voice with the drum and trumpet.

This animal's sense of smelling is not only exquisite, but it is pleased with the same odours that delight mankind. The elephant gathers flowers with great pleasure; it picks them up one by one, unites them in a nosegay, and seems charmed with the perfume. The orange-flower is particularly grateful, both to its taste and smell; it strips the tree of all its verdure, and eats every part of it, even to the branches themselves. It seeks in the meadows the most odoriferous plants to feed upon; and in the woods it prefers the cocoa, the banana, the palm, and the sage-tree to all others.

But it is in the sense of feeling that this animal excels all others of the brute creation, and perhaps man himself. The organ of this

sense is wholly in the trunk, which is an instrument peculiar to this animal; and that serves it for all the purposes of a hand. The trunk ends in two openings, or nostrils, like those of a hog. An elephant of fourteen feet high, has the trunk about three feet long, and five feet and a half in circumference, at the mouth. It is hollow all along, but with a partition running from one end of it to the other. This tube is composed of nerves and muscles covered with a skin like that of the rest of the body. It is capable of being moved in every direction, of being lengthened and shortened, of being bent or straightened; so pliant as to embrace any body it is applied to, and yet so strong that nothing can be torn from its gripe. To aid the force of this grasp, there are several very little eminences, like a caterpillar's feet, on the under side of this instrument, which without doubt contributes to the sensibility of the touch as well as the firmness of the hold. Through this trunk the animal breathes, drinks and smells; and at the very point of it, just above the nostrils, there is an extension of the skin, above five inches long, in the form of a finger, and which, in fact, answers all the purposes of one; for with the rest of the extremity of the trunk, it is capable of assuming different forms at will, and, consequently, of being adapted to the minutest objects. By means of this, the elephant can untie the knots of a rope, unlock a door, and even write with a pen. It sometimes happens, that the object is too large for the trunk to grasp; in such a case the elephant makes use of another expedient. It applies the extremity of the trunk to the surface of the object, and, sucking up its breath, lifts and sustains such a weight as the air in that case is capable of keeping suspended. In this manner this instrument is useful in most of the purposes of life; it is an organ of smelling, of touching, and of suction; it not only provides for the animal's necessities, but it also serves for ornament and defence.

The legs are not so inflexible as the neck, yet they are very stiff, and bend not without difficulty. Those before, seem to be longer than the hinder; but, upon being measured, are found to be something shorter. The joints by which they bend are nearly in the middle, like the knee of a man, and the large bulk which they are to support, makes their flexure ungain. Yet while the elephant is young, it bends the legs to lie down or rise; but when it grows old or sickly, this becomes so inconvenient that the animal chooses to sleep standing.

It is one of the striking peculiarities of this animal, that his generative powers totally fail when he comes under the dominion of man; as if he seemed unwilling to propagate a race of slaves to increase the pride of his conqueror.

The elephant, when once tamed, becomes the most gentle and obedient of all animals. It soon conceives an attachment for the

person that attends it, caresses him, obeys him, and seems to anticipate his desires.

In a short time it begins to comprehend the signs made to it, and even the different sounds of the voice; it perfectly distinguishes the tone of command from that of anger or approbation, and acts accordingly. It receives its orders with attention; eagerly, yet without precipitation. All its motions are regulated, and its actions seem to partake of its magnitude, being grave and majestic. It is quickly taught to kneel down to receive its rider; it caresses those it knows with its trunk; with this salutes such as it is ordered to distinguish, and with this, as with a hand, helps to take up part of its load. It suffers itself to be arrayed in harness; and seems to take a pleasure in the finery of its trappings. It draws either chariots, cannons, or shipping, with surprising strength and perseverance; and this with a seeming satisfaction, provided its master appears pleased with its exertions. And he frequently takes such an affection for his keeper that he will obey no other: and it has been known to die for grief, when in some sudden fit of madness, it has killed its conductor.

In Delhi, an elephant passing the streets, put his trunk into a tailor's shop, where several people were at work. One of the persons of the shop, desirous of amusement, pricked the animal's trunk with his needle. The elephant passed on without any signs of resentment, but coming to a puddle of dirty water, filled his trunk, returned to the shop, and spirted it over all their finery.

Some of them are twenty feet in compass, and near fourteen high. They seem to have more sense than any other brute, and are capable of fidelity and strong affection: particularly to their companion: so that neither the male nor female is ever known to make a second choice.

The female goes seventeen months with her young: they are fifty or sixty years before they have their full strength, are in full vigour at about a hundred, and live two or three hundred years.

A RHINOCEROS, next to the elephant, is the most extraordinary animal in the Indies. It is usually twelve feet long, from the tip of the nose to the insertion of the tail; from six to seven feet high; and the circumference of its body is nearly equal to its length. It is therefore equal to the elephant in bulk, and if it appears much smaller to the eye, the reason is, the legs are much shorter. In other respects it is shaped like a wild boar.

It is said to have a very rough tongue, but this is so far from the truth, that no animal of near its size has so soft a one. It is smooth and small like that of a dog; and to the feel, it appears as if one passed the hand over velvet. It has a peculiar cry, a mixture between the grunting of a hog, and the bellowing of the calf. The age

of these animals is not well known: it is said by some, that they bring forth at three years old, and if we may reason from analogy, it is probable they seldom live above twenty.

That which was shewn in London, was said, by its keeper, to be eighteen years old, and even at that age, he pretended to consider it as a young one; however it died shortly after, and that probably in the course of nature. It is a native of Asia and Africa, and is usually found in those extensive forests that are frequented by the elephant and lion. As it subsists entirely upon vegetable food, it is peaceful and harmless among its fellows of the brute creation; but though it never provokes to combat, it equally disdains to fly. It is every way fitted for war, but rests contented in the consciousness of its security.

His skin is without hair, and so full of scratches and scabs, that at a distance they may well be taken for scales. On his nose he has a horn of a dark brown colour, which bends backward, and is often two feet long. He has often another horn a little above this, which never exceeds six inches. His eyes are exceeding small, and he only sees straight forward: therefore he always runs in a straight line tearing up whatever stands in his way. With his horn he throws stones over his head to a great distance, and even tears up trees by the roots.

The outer skin of the rhinoceros, which consists of many folds, is thick and impenetrable. In running one's fingers under one of the folds, it feels like a board half an inch thick. But between the folds the skin is as smooth and soft as silk, and easily penetrated. See here the wisdom of the great Creator! If the outer skin, which is quite inflexible, was continued all over him without any fold, he could not perform any action whatever. But the suppleness of skin in other beasts, is compensated in this by these folds. It was necessary his skin should be hard for his defence: mean time it was a noble contrivance, that it should be so soft and smooth underneath, that when he bends himself any way, one part of this board-like skin, should slide over the other. And these folds are placed in such parts of his body as to facilitate the performance of every voluntary motion.

Another native of the East-Indies is the CAMEL,* one of the most serviceable animals in the world. He kneels down to receive his

* The Arabians regard the camel as a present from heaven, on which their living and comfort chiefly depend. Its milk is their ordinary food, and is extremely nourishing: they also eat its flesh, which is highly savoury. Of its hair which is very fine and soft, and which is renewed every year, they clothe themselves. Their camels serve them for defence against their enemies: in one day they can perform a journey of fifty leagues into the desert, which cuts off every approach from their enemies. All the armies in the world would perish in pursuit of a troop of Arabs. The camel constitutes the real wealth of Asia; he supersedes the

burden, and rises when he hath his accustomed load. If he feels himself over burdened he will not rise, but cry till part of it is taken off. One of them will carry a thousand or twelve hundred weight, forty miles a day, for thirty or forty days together. They have no teeth in the upper jaw. They will travel forty hours, without either meat or drink: and nine days without drink: they have two stomachs admirably contrived for this purpose. The gentlemen who dissected one at Paris, found in his second stomach several square holes, which were the orifices of about twenty cavities, made like sacks, placed between the two membranes, which compose the substance of the stomach. And in these reservoirs he contains water enough to serve him for so many days.

The bunch on his back is not flesh, much less bone, but mere hair. And when this is prest close down, he is no more bunch-backed than a swine. They subsist on very little, which enables them to travel through those vast and barren deserts. How wise is He who caused these to be natives of those countries, where such creatures are absolutely necessary! A farther instance of this is, that the African camel, which has still greater and more uncouth journeys to take, is larger and stronger, and capable of carrying heavier burdens than those of Asia.

Another wonderful property of camels is, that of foreseeing the poisonous winds, which kill in a moment. A little before these come, they run together and cry, and hide their noses in the earth. And as soon as they are past, they lift up their heads, and continue their journey.

value of gold, silver, and other precious commodities. He is more valuable than the elephant, he performs an equal quantity of labour with a twentieth part of the expence. Besides the whole species are subject to man, who propagates and multiplies them at pleasure; he is not only more valuable than the elephant, but perhaps equal in utility to the horse, the ox, and the ass united. He carries as much as two mules, eats as little, and feeds upon herbs equally course as the ass. The camel also supplies them with medicine, for the cure of their wounds and the restoration of their health, even its excrements are useful; with the urine they make sal amoniac, and the dung serves them for fuel, which is excellent, it burns freely, and gives as clear, and nearly as hot a fire as dry wood, this is a great accommodation in the deserts where not a tree or shrub is to be found, and for want of combustible materials, fire is as scarce as water. The dung also serves for straw and numerous other useful purposes. In short, this creature considered altogether, is perhaps the most useful animal in creation. He is a carriage for their persons, and a carriage for their merchandise, and is equally adapted for pleasure, and for service. With the possession of such a creature the people of its native regions, think themselves the most highly favoured, and the happiest people on earth, and not without some colour of reason; and when they are told, there are parts of the earth where there are no camels, they express a wonder how a people can exist, without camels.

The DROMEDARY in most respects resembles the camel; only it is of a slighter make, and instead of one bunch on its back, has two about six inches in height. It goes frequently forty leagues a day; so that although it cannot carry above six hundred weight, yet its swiftness atones for its weakness. Its feet are soft as a sponge, and are not hurt, either by stones or sand. And, what is an excellent providence, they travel best, and have the greatest spirits in the hottest weather.

The LAMAS, in Peru, have small heads, resembling in some measure both a horse and a sheep. The upper lip is cleft, like that of a hare, through which, when they are enraged, they spit, even to ten paces distance, a sort of juice, which when it falls upon the skin, causes a red spot and great itching. The neck is long, like that of a camel, the body like that of a sheep, but with much longer legs. It yields strong and fine wool, and is also a beast of burden, and kept at an easy expence. It carries a burden, a vast way, without tiring; eats very little, and never drinks. At night he lies down, and no blows can make him rise, or move one foot till morning.

A creature no less remarkable, but in a quite different way, is the CASTOR, or BEAVER. This creature is about four feet long, and fifteen inches broad. He is covered with two sorts of hair, one long, the other a soft down. The down, an inch long, is properly his clothing, being extremely fine, and close laid upon the skin. The long hair is spread over all, to preserve it from dirt and wet.

Whether male or female, it has two bags under its belly, which contain a liquid substance, that congeals in air, and affords an excellent medicine, which we call castoreum.

He hath strong teeth rivetted fast in his jaws, to cut wood, as well as chew his food. His fore feet are like those of an ape or squirrel, to hold what he eats in his paw. And with these he digs, softens, and works the clay or loam for his habitation. His feet are remarkably formed, more proper to swim than to walk with, the five toes being joined together by a strong membrane. His tail is long, flattish, covered with scales, and constantly lubricated with oil; because, being an architect from his birth, he uses his tail as a hod, to carry his clay or mortar, and as a trowel, to spread it into an incrustation. Mean time the scales preserve it from being hurt by the burden; and the oil which he squeezes from his bags, and rubs on with his snout, from the noxious air and water.

As they like to live together, they choose a situation near some rivulet. They first build a causeway, in which the water may rise level with the first story of their habitation. This is built of wood and clay, about twelve feet thick at the bottom, descending in a slope on the side next the water. The other side is perpendicular: the top of

this is about two feet broad. They cut their wood, though as thick as one's thigh, into pieces from two to six feet long, drive them into the earth with their teeth, and lace them together with boughs, closing all the openings within and without with a strong plaister made of clay. If the water increase upon them, they raise their wall higher. Knowing their materials are more easily brought by water than by land, they watch its increase, to swim with mortar on their tails, and stakes between their teeth to the place where they build. When the causeway is finished, they begin their apartments, which are oval, and divided into three partitions, one above another. But the walls of these are perpendicular, and only two feet thick. All the wood that projects, they cut off with their teeth: and rough-cast both the out and inside of their work, with a mixture of clay and dry grass. The first partition being below the level of the dyke is full of water; for they love to have their hinder part hanging in the water. The other two are above it, so that if the water ascend, they may ascend proportionably.

At the bottom of their building, they strike out two openings to the stream; one leads to the place where they bathe, the other to that where they ease nature.

They associate ten or twelve together, and proportion their house to their number. When all is finished below, they vault the top or roof in an oval form.

In summer they feed on fruits and plants: in winter, on willow, ash, or other wood. This they collect and store up in time. They cut boughs from three to six feet long: the large pieces are brought to the magazine by several beavers, the smaller by one alone; but they take different ways, each having his path assigned, to prevent the labour being interrupted. They build up their pile with much art, which is proportioned to their number. A square pile of thirty feet, about ten feet deep, serves for ten beavers. But the wood is not piled up in one continued heap: the pieces are laid across one another, with cavities between, for the conveniency of drawing out what they want. They always use first the parcel at bottom, which lies in the water. And when it is taken up for use, they cut this wood into small pieces, and convey it to their apartment, where the whole family come and receive their shares.

The feet of a female beaver, which a gentleman kept in England some years since, were webbed, like those of a goose. The tail was scaly, and shaped like the blade of an oar. This she used as a rudder to steer herself, especially when she swam under water, which she would do for two or three minutes, and then come up to take breath, sometimes raising only her nostrils above water. She swam swifter than any water fowl; and under water as swift as a carp. The hind legs being

longer than the fore, make her walk slow on dry land, or rather waddle like a duck. If drove along fast, she could not run, but went by jumps, flapping her tail against the ground. She never made any noise, except a little sort of a grunting, when angry, or driven fast. As the beaver frequents the water like water fowls, may not the castor be provided for him by nature, to anoint his fur with, and prevent the water from soaking to his skin. And as it is impregnated with penetrating, pungent particles, it may likewise contribute to keep off the chill, which the water might otherwise strike to his body, when he remains long therein.

The SHAMMOY, though a wild animal, is easily tamed, and is to be found only in rocky and mountainous places. It is about the size of a domestic goat. It is agreeably lively, and active beyond expression. The shammoy's hair is short, like that of a doe. In spring it is of an ash colour; in autumn, a dun colour, inclining to black; and in winter, of a blackish brown. This animal is found in great plenty in the mountains of Dauphiny, of Piedmont, Savoy, Switzerland and Germany. They are peaceful, gentle creatures, and live in society with each other. They are found in flocks of from four to fourscore, dispersed upon the crags of the mountains. The large males are seen feeding detached from the rest, except in rutting time, when they approach the females, and drive away the young.

It is to be observed, that this creature is extremely vigilant, and has an eye the most piercing in nature. Its smell also is not less distinguishing. When it sees its enemy distinctly, its stops for a moment: and then if the person be near, in an instant flies off. In the same manner it can, by its smell, discover a man at a great distance, and gives the earliest notice. Upon any alarm, the shammoy begins his hissing note with such force, that the rocks and forests re-echo to the sound. The animal having reposed a moment, again looks round, and perceiving the reality of his fears, continues to hiss by intervals. During this time, it seems in the most violent agitation; it strikes the ground with its fore foot, and sometimes with both; it bounds from rock to rock; it turns and looks round; it runs to the edge of the precipice, and still flies with all its speed.

Its head is furnished with two small horns, of about half a foot long, of a beautiful black. The ears are placed in a very elegant manner, near the horns; and there are two stripes of black on each side of the face, the rest being of a whitish yellow, which never changes. They run along the rocks with great ease and indifference, and leap from one to another, so that no dogs are able to pursue them. They always mount or descend in an oblique direction; and throw themselves down a rock of thirty feet, and light with great security upon some excrescence or fragment, on the side of the precipice, which is

just large enough to place their feet upon. The more craggy and uneven the forest, the more this animal is pleased with the abode which thus adds to its security.

The ROE-BUCK is the smallest of the deer kind in our climate, and is now almost extinct, except in the highlands of Scotland. It is generally about three feet long, and about two feet high. The horns are from eight to nine inches long, upright, round, and divided into three branches. The body is covered with very long hair, well adapted to the rigour of its mountainous abode.

As the stag frequents the thickest forests, and the sides of the highest mountains, the roe-buck courts the shady thicket and the rising slope. Although far inferior in strength to the stag, it is more active, and even more courageous. Its hair is always smooth, clean, and glossy; and it frequents only the driest places, and of the purest air. Though but a very little animal, yet, when its young are attacked, it faces the stag himself, and often comes off victorious. All its motions are elegant and easy; it bounds without effort, and continues the course with little fatigue. It is also possessed of more cunning in avoiding the hunter; and, although its scent is much stronger than that of the stag, it is more frequently found to make good a retreat. The stag never offers to use art until his strength is beginning to decline; this more cunning animal, when it finds that its first efforts to escape are without success, returns upon its former track, again goes forward, and again returns, until by its various windings, it has entirely destroyed the scent, and joined the last emanations to those of its former course. It then, by a bound, goes to one side, lies flat upon its belly, and permits the pack to pass by very near, without offering to stir.

The roe-buck differs from the stag also, in its natural appetites, its inclinations, and its whole habit of living. Instead of herding together, these animals live in separate families; the sire, the dam, and the young ones, associate together, and never admit a stranger into their little community. All others of the deer kind are inconstant in their affection; but the roe-buck never leaves its mate; and as they have been generally bred up together from their first fawning, the male and female never after separate.

They drive away their fawns upon these occasions; the buck forcing them to retire in order to make room for a succeeding progeny. However, when the season is over, the fawns return to their does, and remain with them some time longer; after which, they quit them entirely, in order to begin an independent family of their own.

When the female is ready to bring forth, she seeks a retreat in the thickest woods, being not less apprehensive of the buck, from whom

she then separates, than of the wolf, the wild-cat, and almost every ravening animal of the forest. She generally produces two at a time. In about ten or twelve days these are able to follow their dam, except in cases of warm pursuit, when their strength is not equal to the fatigue. Upon such occasions, the tenderness of the dam is very extraordinary; leaving them in the deepest thicket, she offers herself to the danger, flies before the hounds, and does all in her power to lead them from the retreat where she has lodged her little ones. Such animals as are nearly upon her own level she boldly encounters: attacks the stag, the wild cat, and even the wolf; and while she has life, continues her efforts to protect her young.

Of all animals of the deer kind, the REIN-DEER is the most useful. It is a native of the icy regions of the north, and cannot live in a more southern climate. Nature seems to have fitted it entirely for that hardy race of mankind that live near the pole. As these would find it impossible to subsist among their barren, snowy mountains, without its aid, so this animal can live only there. From it alone, the natives of Lapland and Greenland supply most of their wants. It answers the purposes of a horse, to convey them and their scanty furniture, from one mountain to another; it answers the purposes of a cow, in giving milk; and of the sheep, in furnishing them with a warm, though a homely kind of clothing. From this alone, therefore, they receive as many advantages as we derive from three of our most useful creatures. It is lower and stronger built than the stag; its legs are shorter and thicker, and its hoofs much broader; its hair is much thicker and warmer; its horns much larger in proportion, and branching forward over its eyes; its ears are much larger; its pace is rather a trot than a bounding, and this it can continue for a whole day; its hoofs are cloven and moveable, so that it spreads them abroad as it goes, to prevent its sinking in the snow.*

* To the Laplanders and other nations of the frozen regions of the North this valuable animal approaches the description of the camel to the Arabians. It is a substitute for the horse, the cow, the goat, and the sheep, and constitutes their only wealth. A man is said to be rich in proportion to the number of his herd. It is not uncommon for those who are esteemed rich to possess a herd of from 10, to 20,000. This creature is of almost universal use to the natives, its milk affords them cheese, its flesh food: its skin clothing: its tendons bow strings, and when split, thread; its horns glue; its bones spoons and other useful implements. During winter it supplies the want of the horse, and draws the sledges with amazing swiftness over the frozen lakes and rivers, or over the snow which at that time covers the whole country, and with these sledges they will travel from 100 to 150 miles in a day; the flesh is excellent food, and is prepared and preserved in a variety of ways, the fat, and the skins are the principal articles of commerce, they abound in amazing numbers near Hudson's Bay, and in March and April they are seen migrating in columns, by thousands from N. to S. driven out of the woods by musquetoes, seeking refreshment on shore, and a quiet place to drop their

Lapland is divided into two districts; the mountainous, and the woody. The mountainous part is barren and bleak, excessively cold, and uninhabitable, during the winter. Still, however, it is the most desirable part of this frightful region, and is most thickly peopled, during the summer. The natives generally reside on the declivity of the mountains, three or four cottages together. Upon the approach of winter, they migrate into the plains below, each bringing down his whole herd, which often amounts to more than a thousand, and leading them where the pasture is in greatest plenty. The woody part of the country is much more hideous: a frightful scene of trees without fruit, and plains without verdure. As far as the eye can reach, nothing is to be seen, even in the midst of summer, but barren fields, covered only with moss; no grass, no flowery landscapes, only here and there a pine tree, which may have escaped the frequent conflagrations, by which the natives burn down their forests. This moss, however, which deforms the country, serves for its only support, as upon it alone the rein-deer can subsist. The inhabitants, who during the summer, lived among the mountains, drive down their herds in winter, and people the plains and woods below.

There is something worthy our notice even in that despised animal, an ass. There is a much greater resemblance between the horse and the ass, than between the sheep and the goat. And yet the latter produce an animal that is not barren; whereas the mule always is.

The she ass is not less fond of her young, than the male is of her. She will rush either through fire or water, to protect or rejoin it. An ass is often no less attached to his owner. He scents him at a considerable distance: he distinguishes him from others, in a crowd. He knows the way wherein he has passed, and the places where he inhabits.

When over-loaded, he shews it by hanging down his head, and lowering his ears. If his eyes are covered, he will not stir a step: and if he is laid down in such a manner that one eye is covered with the grass, while the other is hidden with a stone, or whatever is next at hand, he will continue fixed in the same situation, and will not so much as attempt to rise, to free himself from those slight impediments. He walks, trots, and gallops, like a horse, but is soon tired; and then no beating will mend his pace. It is in vain that his unmerciful rider

young. The beats of prey follow these herds, first the wolves, who single out the straglers (for they fear to attack the drove) detach and hunt them down; the foxes attend at a distance, to pick up the offals left by the former: in autumn the deer with their fawns re-migrate Northward. The Indians are very attentive to these movements as they furnish their chief subsistence, they kill multitudes of them for the sake of their tongues only; which they preserve, by drying them in the smoke.

exerts his whip or his cudgel: the poor little animal bears it all with patience, and does not offer even to move.

The Spaniards, of all people in Europe, seem to be acquainted with the value of the ass. They take all precautions to improve the breed, and the jackass in Spain is above fifteen hands high. This animal, however, seems originally a native of Arabia. A warm climate is known to produce the largest and the best: their size and spirit decline, in proportion as they advance into colder regions.

In Guinea, they are larger and more beautiful, than even the horses of the same country.

In Persia, they have two kinds; one of which is used for burdens, being slow and heavy, the other is kept for the saddle, being smooth, stately, and nimble. An ass will live about sixty years. He sleeps much less than the horse; and never lies down for that purpose, unless very much tired. The she ass goes about eleven months with young, and never brings forth more than one at a time.

The mule may be engendered, either between a horse and a she ass, or between a jackass and a mare. The latter breed is every way preferable, being larger, stronger, and better shaped. The common mule is found very serviceable in carrying burdens, particularly in mountainous and stony places. Their manner of going down the precipices of the Alps is very extraordinary. In these passages, on one side, are steep eminences, and on the other, frightful abysses; and, as they generally follow the direction of the mountain, the road, instead of lying in a level, forms at every little distance steep declivities, of several hundred yards downward. These can only be descended by mules: and the animal itself seems sensible of the danger. When they come to the edge of one of these descents, they stop of themselves, without being checked by the rider; and if he inadvertently attempts to spur them on, they continue immoveable. They seem ruminating and preparing themselves for the encounter. They not only attentively view the road, but tremble and snort. Having prepared for the descent, they place their fore feet in a posture, as if they were stopping themselves: they then put their hinder feet together, but a little forward, as if they were going to lie down. In this attitude, having taken as it were a survey of the road, they slide down with the swiftness of a meteor. In the mean time, all the rider has to do is to keep himself fast on the saddle, without checking the rein, for the least motion is sufficient to disorder the mule; in which case they both unavoidably perish. But their address in this rapid descent is truly wonderful; for in their swiftest motion, when they seem to have lost all government of themselves, they follow exactly the different windings of the road, as if they had previously settled in their minds the route they were to follow. In this journey, the

natives, who are placed along the sides of the mountains, and hold by the roots of the trees, animate the beast with shouts, and encourage him to perseverance.

There are but three animals of the horse-kind. The HORSE, which is the most stately and courageous, the ASS, which is the most patient, and the ZEBRA, which is the most beautiful, but at the same time the wildest animal in nature. Nothing can exceed the delicate regularity of this creature's colour, or the smoothness of its skin; but on the other hand, nothing can be more timid or more untameable.

The zebra, or wild ass, is chiefly a native of the southern parts of Africa, and there are whole herds of them often seen feeding in the extensive plains near the Cape of Good Hope. However, their watchfulness is such, that they suffer nothing to come near them; and their swiftness so great, they readily leave their pursuers far behind. The zebra, in shape, rather resembles the mule than the ass. Its ears are not as long as those of the ass, and yet not so small as in the horse-kind. Like the ass, its head is large, its back straight, and its tail tufted at the end; like the horse, its skin is smooth and close, and its hind quarters round and fleshy. But its greatest beauty lies in the amazing elegance of its colours. In the male they are white and brown; in the female, white and black. These colours are disposed in alternate stripes over the whole body, and with such exactness and symmetry, that one would think nature had employed the rule and compass to paint them. These stripes, which are like so many ribbons laid all over its body, are narrow, parallel, and exactly separated from each other.

It is now not known, what were the pains and the dangers which were first undergone to reclaim the breed of horses from savage ferocity: these, no doubt, made an equal opposition; but by being opposed by an industrious and enterprising race of mankind, their spirit was at last subdued, and their freedom restrained.

It is otherwise with regard to the zebra; it is the native of countries where the human inhabitants are but little raised above the quadruped. The natives of Angola or Cafraria, have no other idea of advantage from horses, but as they are good for food; neither the fine stature of the Arabian courser, nor the delicate colourings of the zebra, have any allurements to a race of people who only consider the quantity of flesh, and not its conformation. The delicacy of the zebra's shape, or the painted elegance of its form, are no more regarded by such, than by the lion that makes it his prey. Perhaps the zebra may have hitherto continued wild, because it is the native of a country where there have been no efforts made to reclaim it. All pursuits then were rather against its life than its liberty: the animal has thus been long taught to consider man as its mortal enemy; and

it is not to be wondered, that it refuses to yield obedience where it has so seldom experienced mercy.

All animals seem perfectly to know their enemies, and to avoid them at the same time ; which we cannot account for. Instinct, indeed, may teach the deer to fly from the lion ; or the mouse to avoid the cat : but what is the principle that teaches the dog to attack the dog-butcher wherever he sees him ? In China, where the killing and dressing dogs is a trade, whenever one of these move out, all the dogs in the village, or the street, are sure to be after him.

I have seen says Dr. G—, more than one instance of the same kind among ourselves. I have seen a poor fellow, who made a practice of stealing and killing dogs for their skins, pursued hue and cry for three or four streets together, by all the bolder breed of dogs, while the weaker flew from his presence with affright.

How these animals could thus find out their enemy, and pursue him, is unaccountable ; but such is the fact ; and it not only obtains in dogs, but in several other animals, though perhaps to a less degree.

The noise of the zebra is neither like that of the horse or ass, but more resembling the confused barking of a mastiff dog. In the two which I saw, there was a circumstance that seems to have escaped naturalists ; which is, that the skin hangs loose below the jaw, upon the neck, in a kind of dewlap, which takes away much from the general beauty.

The SQUIRREL is a beautiful little animal : which from the gentleness of its manners, deserves our protection. It is not hurtful, its usual food is fruits, nuts and acorns ; it is cleanly, nimble, active, and industrious ; its eyes are sparkling, and its physiognomy marked with meaning. It generally, like the hare and rabbit, sits upon its hinder legs, and uses the fore paws as hands ; these have five claws as they are called, and one of them is separated from the rest like a thumb. This animal seems to approach the nature of a bird, from its lightness and surprising agility. It seldom descends to the ground, except in case of storms, but jumps from one branch to another ; feeds in spring, on the buds and young shoots ; in summer, on the ripening fruits : and particularly the young cones of the pine tree. In autumn it has an extensive variety, the acorn, the filbird, the chesnut, and the wilding. This season of plenty, however, is not spent in idle enjoyment ; the provident little animal gathers at that time its provisions for the winter, and cautiously forsees the season when the forest shall be stripped of its leaves and fruitage.

Its nest is generally formed among the large branches of a great tree, where they begin to fork off into small ones. After choosing the place where the timber begins to decay, and a hollow may easily be formed, the squirrel begins by making a kind of level between the

forks; and then bringing moss, twigs, and dry leaves, it binds them together with great art, so as to resist the most violent storm. This is covered on all sides, and has but a single opening at top, which is just large enough to admit the little animal; and this opening is itself defended from the weather, by a kind of canopy that throws off the rain, though never so heavy. The nest, thus formed, with a very little opening above, is, nevertheless, very commodious and roomy below; soft, well knit together, and every way convenient and warm. In this retreat the little animal brings forth its young, shelters itself from the heat of the sun, which it seems to fear, and from the storms and inclemency of the winter, which it is still less capable of supporting. Its provision of nuts and acorns is seldom in its nest, but in the hollows of the tree, laid up carefully together, and never touched but in cases of necessity. Thus one single tree serves for a retreat and a storehouse, and without leaving it during the winter, the squirrel possesses all those enjoyments that its nature is capable of receiving.

The MARMOT is almost as big as a hare, but is more corpulent than a cat, and has shorter legs. Its head pretty nearly resembles that of a hare, except that its ears are much shorter. It is clothed all over with very long hair, and a shorter fur below. These are of different colours, black and grey.

The length of the hair gives the body the appearance of greater corpulence than it really has, and at the same time shortens the feet so that its belly seems to touch the ground. Its tail is tufted and well furnished with hair, and it is carried in a straight direction with its body. It has five claws behind, and only four before. These it uses as the squirrel does, to carry its food to its mouth, and it usually sits upon its hinder parts to feed in the manner of that little animal. It is readily taught to dance, to wield a cudgel, and to obey the voice of its master. Like the cat, it has an antipathy to the dog, and when it becomes familiar to the family, and is sure of being supported by his master, it attacks and bites even the largest mastiff. From its squat, muscular make, it has great strength joined to great agility.—However, it is in general a very inoffensive animal; and, except its enmity to dogs, seems to live in friendship with every creature, unless when provoked. As its legs are very short, and made somewhat like those of a bear, it is often seen sitting up, and even walking on its hind legs. Like all the hare kind, it runs much swifter up hill than down; it climbs trees with great ease, and runs up the clefts of rocks, or the contiguous walls of houses, with great facility.

Those arms which the HEDGE-HOG possesses in miniature, the PORCUPINE has in an enlarged degree.

In the one, the spines are but an inch long: in the other a foot. The porcupine is about two feet long, and fifteen inches high. It is

covered with quills from ten to fourteen inches long, resembling the barrel of a goose quill in thickness; but tapering and sharp at both ends. Each quill is thickest in the middle; and inserted into the animal's skin, in the same manner as feathers in birds. The biggest are often fifteen inches long, and a quarter of an inch in diameter; extremely sharp, and capable of inflicting a mortal wound. They are harder than common quills, and solid at the end which is not fixed in the skin. All these quills incline backwards, like the bristles of a hog; but when the animal is irritated, rise, and stand upright.

Such is the formation of this quadruped, in those parts in which it differs from most others. As to the rest of its figure, the muzzle bears some resemblance to that of a hare, but black; the legs are very short, and the feet have five toes, both before and behind; and these, as well as the belly, the head, and all other parts of the body, are covered with a sort of short hair, like prickles; there being no part, except the ears and the sole of the foot, that is free from them: the ears are thinly covered with very fine hair; and are in shape like those of mankind: the eyes are small like those of a hog, being only one third of an inch from one corner to the other. After the skin is taken off, there appears a kind of paps on those parts of the body from whence the large quills proceed; these are about the size of a small pea, each answering to as many holes as appear on the outward surface of the skin, and which are about half an inch deep, like as many hollow pipes, wherein the quills are fixed, as in so many sheaths.

This animal partakes much of the nature of the hedge-hog; having this formidable apparatus rather to defend itself, than annoy the enemy. Indeed many have supposed that it was capable of discharging at its foes its quills. But, it is now well known that its quills remain fixed in the skin, and are then only shed when the animal moults them, as birds do their feathers.

The PANGOLIN, a native of the torrid climates of the ancient continent, is, of all animals, the best protected from external injury. It is three or four feet long, or taking in the tail, from six to eight. It has a small head, a very long nose, a short thick neck, a long body, legs very short, and a tail extremely long. It has no teeth, but is armed with five toes on each foot, with long white claws. But what it is chiefly distinguished by, is its scaly covering. These scales defend the animal on all parts, except the under part of the head and neck, under the shoulders, the breast, the belly, and the inner side of the legs; all which parts are covered with a smooth, soft skin, without hair. The scales of this extraordinary creature are of different sizes and different forms, and stuck upon the body somewhat like the leaves of an artichoke. The largest are near the tail, which is covered

with them like the rest of the body. These are above three inches broad, and about two inches long; thick in the middle, and sharp at the edges. They are extremely hard, like horn. They are convex on the outside, and a little concave on the inner; one edge sticks in the skin, while the other laps over that immediately behind it. Those that cover the tail are so hard, when the animal has acquired its full growth, as to turn a musket ball.

This lapped round the rest of the body, and being defended with shells even more cutting than any other part, the creature continues in perfect security. Its shells are so large, so thick, and so pointed, that they repel every animal of prey; they make a coat of armour that wounds while it resists, and at once protects and threatens. The most cruel beasts of the forest, the tiger, the panther, and the hyæna, make vain attempts to force it. They roll it about, but all to no purpose; the pangolin remains safe while its invader feels the reward of its rashness.

The ARMADILLO is chiefly an inhabitant of South America: a harmless creature, incapable of offending any other, and furnished with a peculiar covering for its own defence.

This animal being covered like a tortoise, with a shell, or rather a number of shells, its other proportions are not easily discerned. It appears, at first view, a round misshapen mass, with a long head, and a very large tail sticking out at either end.

It is of different sizes, from a foot to three feet long, and covered with a shell, divided into several pieces, that lap over each other, like the plates in the tail of a lobster. This covers the head, the neck, the back, the sides, the rump, and the tail, to the very point. The only parts to which it does not extend are, the throat, the breast, and the belly, which are covered with a white soft skin. By this means the animal has a motion in its back, and the armour gives way to its necessary inflexions. These shells are differently coloured in different kinds, but most usually they are of a dirty grey. This colour in all arises from another peculiar circumstance in their conformation; for the shell itself is covered with a softish skin, which is smooth and transparent.

BEASTS may be considered as a numerous groupe, terminated on every side by some that but in part deserve the name. On one quarter we see a tribe covered with quills, or furnished with wings, that lift them among the inhabitants of the air; on another, we behold a diversity clothed with scales and shells, to rank with insects; and still, on a third, we see them descending into the waters, to live among the mute tenants of that element. We now come to a numerous tribe, that seem to make approaches even to humanity; that

bear an awkward resemblance to the human form, and discover the same faint efforts at intellectual sagacity.

Animals of the MONKEY class are furnished with hands instead of paws; their ears, eyes, eye-lids, lips, and breasts, are like those of mankind; their internal conformation also bears some distant likeness; and the whole offers a picture that may mortify the pride of such as make their persons the principal objects of their admiration.

These approaches, however, are gradual and some bear the marks of our form, more strongly than others.

In the APE-kind, we see the whole external machine strongly impressed with the human likeness; these walk upright, want a tail, have fleshy posteriors, have calves to their legs, and feet nearly like ours.

In the BABOON-kind, we perceive a more distant approach; the beast mixing in every part of the animal's figure: these generally go upon all fours; but some, when upright, are as tall as a man: they have short tails, long snouts, and are possessed of brutal fierceness.

The MONKEY-kind are removed a step further: these are much less; with tails as long as their bodies, and flattish faces.

Lastly, the OPOSSOM-kind, seem to lose all resemblance of the human figure, except in having hands; their noses are lengthened out, and every part of their bodies totally different from the human; however, as they grasp their food with one hand, which beasts cannot do, this simple similitude gives them an air of sagacity, to which they have scarce any other pretensions.

The BABOON is from three to four feet high, very strong built, with a thick body and limbs, and canine teeth, much longer than those of men. It walks more commonly upon all fours than upright, and its hands as well as its feet are armed with long, sharp claws, instead of the broad, round nails, of the ape kind.

At the Cape of Good Hope, they are under a sort of natural discipline, and go about whatever they undertake with surprising skill and regularity. When they set about robbing an orchard or vineyard, for they are extremely fond of grapes and apples, they go in large companies, and with preconcerted deliberation, part of them enter the enclosure, while one is set to watch. The rest stand without the fence, and form a line reaching all the way from their fellows within to their rendezvous without, which is generally in some craggy mountain. Every thing being thus disposed, the plunderers within the orchard throw the fruit to those that are without, as fast as they can gather it; or, if the wall or hedge be high, to those that sit on the top; and these hand the plunder to those next them on the other side. Thus the fruit is pitched from one to another all along the line,

till it is safely deposited at their head quarters. They catch it as readily as the most skilful tennis-player can a ball; and while the business is going forward, a profound silence is observed. Their sentinel, during this whole time, continues upon the watch, and if he perceives any one coming, instantly sets up a loud cry, on which signal, the whole company scamper off. Nor yet are they willing to go empty handed; for if they be plundering a bed of melons, for instance, they go off with one in their mouths, one in their hands, and one under their arm. If the pursuit is hot, they drop first that from under their arm, then that from their hand; and, if it be continued, they at last let fall that which they had kept in their mouths.

The CHIMPANASE is an animal found in Angola, nearly approaching to the human figure: but of a fierce disposition, and remarkably mischievous. In the year 1738, one of these creatures was brought over to England. It was about twenty months old. [The parent had it in her arms when she was killed: she was five feet high.] It was of the female sex, naturally walked erect, was hairy on some part of the body and limbs, and of a strong, muscular make. It would eat any coarse food, but was very fond of tea, which it drank out of a cup, with milk and sugar, as we do. It slept in the manner of the human species, and its voice resembled the human, when people speak very hastily; but without any articulate sounds. The males of this species are very bold, and will fight a man, though he is armed. It is said, they often assault and ravish the negro women, when they meet them in the woods.

There is another strange species of monkey found in the West-Indies, of the size of a fox. Its face is raised high, its eyes black and shining, and its ears small and round. His hairs are so nicely disposed all over the body, that he appears perfectly smooth; and they are much longer under the chin, so that they form a kind of beard there.

These are found in great numbers in the woods, and make a loud and frightful noise. But it is very common for one only to make a noise, and the rest to form a mute assembly round him.

Marcgrave says, "I have frequently found great numbers of them, meeting about noon: at which time they formed a large circle, and one placing himself above the rest, began to make a loud noise. When he had sung thus by himself, for some time, the rest all remaining silent, he lifted up his hand, and they all instantly joined in a sort of chorus. This intolerable yell continued till the same monkey, who gave the signal for their beginning, lifted up his hand a second time. On this they were all silent again, and so finished the business of the assembly."

The OPOSSUM is about the size of a cat, only more corpulent, and its legs more robust. It is of a kind of chesnut colour, very bright and glossy. Its head is long, and terminates in a snout, somewhat like a fox's. The tail is long, and much resembles that of a rat, which it twists about with a surprising facility. The legs being short, the body is carried at no great distance from the ground. On the belly of the female, a bag is formed by the skin being doubled. It is not very deep, the closest part being toward the upper part of the body, and the open part toward the lower. This is covered with fur, like the rest of the body, so that it is not very obvious to the sight.

It is a harmless, but likewise a defenceless animal: and the young of no creature are produced so small and tender, in respect of the parent animal. Therefore that bag is extremely useful to them. They are cherished there by the warmth of the parent's body, till toward noon: then they go abroad, till at the first warning by the evening cold, they retire into their lodging again. Nor is this all the help which it affords: for as the tender young of the opossum are delicate morsels, they would be exposed to the rage of many animals, both by day and night. But the body of the parent is a safe and ready receptacle for them. By day she is as watchful over her brood, as a hen over her chickens. She is alarmed at the slightest appearance of danger, and by a noise which they well understand, instantly calls them into her bag. At night she constantly takes them in, and consults for herself and them in a very uncommon manner. There are those among the devourers of her young, who will climb a tree after her. Therefore, when she has climbed, to secure herself and her young still farther, she twists her tail twice round some small bough, and then drops from it. There she hangs with her head downward: and whenever she pleases she recovers the branch with her feet, by a swing, and loosening her tail, walks about as usual.

To enable her thus to hang, there are spikes or hooks in the under side of the vertebre of the tail. Indeed, in the first three vertebre there are none: for there they would be of no use. But they are found in all the rest. They are placed just at the articulation of each joint, and in the middle from the sides. Nothing could be more advantageously contrived. For when the tail is twisted round a bough, these hooks easily sustain the weight. And there is no more labour of the muscles required, than just to bow or crook the tail.

Another animal of a very peculiar kind is an ICHNEUMON. It is of the weasel kind, with a longer and narrower body than the cat, something approaching to the shape and colour of a badger. Its nose is black and sharp, like that of a ferret. Its colour is a yellowish grey. Its legs are short, and each of its feet has five toes. Its tail is very

long; its teeth and tongue much like those of a cat. It is a very cleanly animal, very brisk and nimble, and of great courage. It will engage a dog, and will destroy a cat by three bites on the throat. But it is quite inoffensive to mankind, and is kept tame in Egypt, running about the house, destroying all vermin, and playing tricks, like spaniels.

When wild, he cannot overtake any nimble animal. But he makes this up by assiduity. His legs being short, he is not much seen; but he has a way of concealing himself yet more, by crawling with his belly close to the ground, which he does all day long. But on the least noise, for his hearing is exceedingly quick, he starts up erect on his hinder legs. If the noise is made by any reptile, bird or small beast, he observes whereabouts it is, places his nose directly in a line with it, and begins to move toward it. He is silent and slow, but constant in his approach; often stopping to hear or look forward, and knows exactly where the creature is: when he is got within about five feet, he stops. Nature, which has denied him speed, has given him strength to leap beyond most other creatures. Having taken good aim, he springs from the place, and falls directly on his prey. Thus he deals with beasts and birds. But to serpents he gives chase, and to avoid their bite, always seizes them by the neck.

Gesnes tells, that the ichneumon is not only an enemy to serpents themselves, but to their eggs also; which he hunts after continually and destroys, though he does not feed upon them. How mercifully has God given this animal in the countries where these terrible reptiles most abound! And which without this provision, would be so overrun with them, as to be uninhabitable.

The JACKAL is of the carnivorous kind. They hunt by scent and go in packs. They pursue with patience, rather than swiftness, and excite each other by a spirit of emulation.

It goes for current that the jackal discovers the lion's prey; that each of these retains one of them, and having satisfied himself, lets his dependents feed on the offals of his repast.

But the truth is, there are great numbers of jackals in some woods, and when one of these sees a stag, or other large beast, which is not a beast of prey, he sets up his cry, which is like that of a hound, and follows it. As he continues his cry, the other jackals that are within hearing follow likewise. And could the creature outrun those that began the chase, there is a continual supply; so that it cannot escape. When they have run it down, they worry it at once, and it is devoured almost in an instant. After this the jackals disperse, till another cry invites them.

They hunt generally in the night, and in the parts of the east, where they are most frequent, there never is a night but they are

heard, in one part or other of the woods. The other beasts of prey understand the sound; and frequently profit by it. If a lion, tyger or leopard happens to be near, he hears the cry, and stands upon the watch. These large animals are all very swift, but they are lazy, and never make long pursuits. If the creature pursued be far off, and runs another way, they never trouble themselves about it. But if it be near, or if it runs towards the place where the lion is, he will dart out upon it as it goes by. And the little animals that hunted it down must stand by, and be content with what their master leaves.

The SABLE-MICE, which were first observed in Lapland, in 1697, are near as big as a small squirrel. Their skin is streaked and spotted with black and light brown. They have two teeth above, and two under, very sharp and pointed. Their feet are like a squirrel's. They are so fierce, that if a stick be held out to them, they will bite it, and hold so fast, that they may be swinged about in the air. In their march they keep a direct line, generally from north east to south west. Innumerable thousands are in each troop, which is usually a square. They lie still by day, and march by night. The distance of the lines they go in, parallel to each other, is of some ells. Whatever they meet in their way, though it were a fire, a deep well, a torrent, lake, or morass, they avoid it not, but rush forward. By this means many thousands of them are destroyed. If they are met swimming over a lake, and are forced out of their course, they quickly return into it again. If they are met in woods or fields and stopt, they raise themselves on their hinder legs, like a dog, and make a kind of barking noise, leaping up as high as a man's knee, and defending their line as long as they can. If at last they are forced out of it, they creep into holes, and set up a cry, sounding like *biab*, *biab*. If a house stands in their way, they never come into it, but stop there till they die. But they will eat their way through a stack of corn or hay. When they march through a meadow, they eat the roots of the grass: and if they encamp there by day, they utterly spoil it, and make it look just as if it had been burnt. They are exceedingly fruitful: but their breeding does not hinder their march. For some of them have been observed to carry one young in their mouth, and another upon their back. In winter they live under the snow, having their breathing holes, as hares and other creatures have.

I would mention only two creatures more, very extraordinary, and yet but little known.

The GLUTTON is frequent in the forests of Germany. It is rarely seen twice of the same figure. It is of the weasel-kind, and is, in its middle state, about the size of a turn-spit dog. Its body is long, its legs short. Its colour is brown, with a reddish tinge; but its breast and belly are white. The tail is long and bushy; the head small and

sharp at the nose. The teeth are exceeding sharp, and the claws sharper than almost in any creature.

This is the most hungry animal in the world, but is ill provided for catching its prey. Most creatures can out-run it, and itself can scarce run away from any thing. But what he wants in swiftness, he has in climbing, which he performs to admiration: its sharp claws enabling it to run up a tree as fast as on the ground. Its usual place is some large and spreading oak, chose both for safety and for catching its prey. He squats all day on some large branch; and if nothing offers below, he preys in the night on whatever creatures he can find on the tree above. Many birds roost on such trees, which he climbs softly to, and devours. But his favourite food is larger animals. He will lie many days on a slanting bough; and when any which he likes comes underneath, he drops down upon them. Hares and rabbits seldom escape him; but he chooses rather a goat, or any creature of that size. When one of these comes under the tree, he creeps from bough to bough, till he comes just over it, and then drops down upon it. He always contrives to fasten on the neck. In an instant, he fixes both his teeth and claws, and lies across the neck, near the shoulders. Here he is secure; and while the poor creature runs with all its speed, he is feeding on its flesh. At length it drops, and he continues eating in the same ravenous manner, till from a mere skeleton, his back becomes round, and his side swelled out like a tun. Still he continues to eat, till he can eat no longer. He too, drops down, and lies panting for breath. He resembles a dead carcase swelled and ready to burst with lying in the sun: and being unable to move for a long time, is frequently destroyed, and sometimes perishes without an enemy.

The God of nature seems to have formed the SLOTH, to represent to us in a strong light, that odious and despicable vice, from which it takes its name. Its body is short, its head small, and it has scarce any tail. Its fur is long, thick, and of a greyish green, so that when seen on the bough of a tree, it appears only like an excrescence or cluster of moss. It is about the size of a cat, but the legs are short, as is the neck; and its long and thick covering, renders it so shapeless, that it seems only an irregular lump of living matter. Its little and remarkably ugly head stands close between the shoulders. The face has much of the monkey aspect. Its small and heavy eyes, are always half shut, and it has no appearance at all of any ears. Its feet are flat and very narrow, but armed with sharp claws, for laying hold on the bark of a tree, by striking deep into it.

He rarely changes his place; and never, but when compelled by absolute necessity. As upon the ground it would be a prey to every other animal, so its constant residence is on a tree. Here it is safe

from all animals, but those who climb these trees for the birds that roost on them. The leaves and tender part of the tree are its food, and serve it for drink as well as meat. It never moves to another branch, till it has devoured all the nourishment upon that where it is stationed: nor from one tree to another, till the first is wholly withered and wasted.

It is observable, the sloth always ascends to the top of a tree, only baiting as he goes, before he begins his devastations. And this is doubtless from the instinctive guidance of nature. For was it to begin eating upward, when it had devoured all, it would have to climb down from the top of a dead tree, and would be half starved in his journey. But this is not all. The havoc which one sloth makes on the largest tree is easily seen. For he eats not only the leaves, but all the buds and bark, leaving only a dead branch: so that unless the same thing might happen by accident, this would betray the creature. It does so happen: and trees then put on the same form, as when they are left by the sloth. But they always die at the top first, and so gradually downward. This animal therefore, wonderfully taught, begins its havoc at the top. As it feeds, the tree decays; but its decay is in the course of nature. The decay spreads downward; and when he has eaten the last of his provision, he is near the ground, and has only to walk away to another tree. But if it is at any distance, his motion is so slow, that he grows quite lean in the expedition.

As the sloth brings forth her young in the hollow of a tree, so is she led by the same wonderful instinct, to conduct them to the topmost branches, as soon as they crawl out. When she is big with young, she climbs some old, hollow tree; and having fixed on a convenient spot for her young, she climbs to the very highest bough, and there feeds faster than usual. When she is full, she descends with unaccustomed haste, and brings forth one, two, or three young ones. It is well she is full fed; for she is to support these with her milk till they can crawl out, without having any supply herself. She is round and fleshy when she retires for this purpose, but a mere skeleton when she comes out. She crawls as well as she can to the part where she left off feeding, and her young follow her. Nor will she touch any thing in the way, however both her hunger and laziness may prompt her to it.

It is the most timorous of all creatures. And with reason; for it can neither fight nor fly. While it is journeying on the ground the tread of a human foot shakes the earth enough to put it into terrors. It trembles: the head is turned about every way, and the mouth is open to cry like a young kitten.

Insignificant as this creature is, there is a special Providence in the formation and care of it. Not designed for walking, its claws enable

it to climb, and then to hold fast in its station. Helpless as it is, the universal Provider has assigned it a place of safety, where it finds plenty of food; and as it cannot easily seek for drink, it has no need of any. To render it the less obnoxious to pursuit, its colour secures it even from view: and its amazing instinct of feeding from the top to the bottom, proves a designing and directing hand.

Before I proceed to some general reflections upon BEASTS, I beg leave to take notice of one circumstance, relating to several species of them, which is very strange, though very common. The horns of many animals fall off every year, and new ones come in their place. Our deer drop them in March, and the new horns are full grown by the July following. We may very justly rank this among the most wonderful phenomena of nature, which yields nothing analogous to the growth of such hard, solid bodies, of so great a bulk, in so short a time. Many idle opinions have been maintained, concerning the cause of their falling off. The truth seems to be this: they are a sort of vegetables, growing on animals, as the nails and hair on man, and feathers on birds. And there is some analogy between the growth of them, and that of branches, and leaves on trees. Trees commonly drop their leaves in autumn, because the nourishing juice flows into them no longer. And at certain periods, these parts of the animal drop off, because the blood and juices cease to flow in them. At this time, the hollow part at the root of the horn grows hard, and the pores, through which the juices passed, grow up. And as no more nourishment can then be carried to the horn, it decays and falls off. It is probable this stoppage of the pores happens as soon as the horns are at their full growth.—But they are so fixed to the head, that it takes a long time for them to loosen and fall. Whereas in leaves, their stalks are so tender, that when the juice ceases to flow, they presently wither and fall.

The analogy between the falling off of deer's horns, and the falling of leaves and ripe fruit from the tree, will receive light from observing the process of nature in the latter case. If the stalk from which a ripe orange has fallen, be compared with that part of a deer's forehead, from which a horn has just fallen it will plainly appear, that nature has operated by the same laws in both. The young horns, while yet soft, are full of blood vessels; and if cut off, especially near the head, bleed violently. By these vessels they are supplied with nourishment for their growth. But these dry up, when there is no farther occasion for them. And hence it is, that no ill symptoms attend the falling off of these parts, when full grown.

So far we may give a probable account: but who can account for this, that if a stag be castrated, while he is so young as not to have horns, he will never have any: and if castrated afterward, while his horns are on, he will never cast them.

10. It remains only to add a few reflections. And first, what admirable wisdom is displayed in the motion of various animals, suited to their various occasions! In some, their motion is swift; in others, slow; and both diversified a thousand ways.

And first, for swift or slow motion. This is exactly proportioned to the occasion of each animal. REPTILES, whose food, habitation and nests lie in the next clod, plant, tree, or hole, or which can bear long hunger, need neither legs nor wings, but their vermicular motion answers all their purposes.

BEASTS, whose occasions require a larger room, have accordingly a swifter motion: and this in various degrees, answerable to their range for food, and the enemies they are to escape from.

But as for BIRDS, who are to traverse vast tracts of land and water, for their food, habitation, breeding their young, and for places of retreat and security, from various inconveniences; they are endowed with the faculty of flying; and that swiftly or slowly, a long or short time, according to their occasions. In all this, the wisdom of God appears, ordering all things well.

Again. How admirable in the motion of all creatures, is the neat, geometrical performance of it! The most accurate mathematician cannot prescribe a nicer motion, than that they perform, to the legs and wings of those that fly or walk, or to the bodies of those that creep. Neither can the body be more completely poised, for the motion it is to have in every creature. From the largest elephant to the smallest mite, the body is exactly balanced. The head is not too heavy, nor too light for the rest of the body, nor the rest of the body for it. The bowels are not loose, or so placed as to swag, overbalance, or overset the body; but well braced, and accurately distributed to maintain the equipoise of it. The motive parts also are admirably well fixed, in respect to the centre of gravity, placed in the very point which best serves to convey the body. Every leg bears its true share of the weight. And the wings are so exactly placed, that even in the fluid medium, the air, the body is as truly balanced, as we could have balanced it with the nicest scales.

Yet again. What an admirable provision is made for the motion of some creatures, by temporary parts! Frogs, for instance, have tails in their tadpole state, which fall out when their legs are grown out. The water-newt also, when young, has four fins, two on a side, to poise and keep the body upright. But as soon as the legs are fully grown, these presently drop off.

Secondly, the bore of the gullet in all creatures, is answerable to their occasions. In a fox, which feeds on bones, as in all ossivorous beasts, it is very large. But in a squirrel it is exceedingly small, lest he should disgorge his meat in his descending leaps; and so in

rats and mice, which often run along a wall with their heads downward.

Thirdly, in all animals the strength and size of their stomach are proportioned to their food. Those whose food is more tender and nutritive, have it smaller, thinner, and weaker. Whereas it is large and strong in those whose food is less nutritive, and whose bodies require large supplies.

All carnivorous beasts have the smallest stomachs, as flesh goes the farthest. Those that feed on fruits and roots have them of a middle size. Sheep and oxen, which feed on grass, have the greatest. Yet the horse, hare, and rabbit, though granivorous, have comparatively small ones. For a horse is made for labour, and both this and the hare for quick and continued motion: for which the most easy respiration, and so the freest motion of the diaphragm is requisite, but this could not be, did the stomach lie big and cumbersome upon it, as it does in sheep and oxen.

Another very remarkable circumstance is, that those animals which have teeth on both jaws, have but one stomach; whereas most of those which have no upper teeth, or no teeth at all, have three stomachs. For the meat which is first chewed, is easily digested; but that which is swallowed whole, requires a stronger concoctive power.

Fourthly, all the parts of the same animal are adapted one to the other. So, for instance, the length of the neck is always proportioned to that of the legs. Only the elephant has a short neck: for the weight of his head and teeth, would to a long neck, have been insupportable. But then he is provided with a trunk, which abundantly supplies the defect. In other beasts and birds, the neck is always commensurate to the legs; so that they which have long legs, have long necks, and they that have short legs, short ones; as may be observed in lizards of all kinds, and the king of them, the crocodile. And creatures that have no legs, as they want no necks, so they have none, as fishes. This equality between the length of the neck and legs, is peculiarly seen in beasts that feed on grass. Their legs and necks are very nearly equal. Very nearly, I say, because the neck must necessarily have some advantage; for it cannot hang perpendicular, but must incline a little.

Moreover, as these creatures must hold their heads down, for a considerable time together, which would be very laborious, and painful for the muscles, therefore on each side of the neck, nature has placed a thick and strong ligament, capable of stretching and shrinking again as need requires: this, which is vulgarly called white leather, extends from the head (to which, and the next vertebre of the neck is fastened at the end) to the middle vertebre of the back, to which it is

knit at the other. And by the assistance of this, they are able to hold their head in that posture all day long.

Fifthly, the parts of all animals are exactly fitted to their manner of living. A notable instance of this is in the swine. His natural food being chiefly the roots of plants, he is provided with a long and strong snout; long, that he may thrust it to a convenient depth in the ground, without offence to his eyes; strong and conveniently formed, for rooting and turning up the ground. And besides, he has an extremely quick scent, for finding out such roots as are fit for him.—Hence in Italy, the usual way of finding truffles, or subterraneous mushrooms, is by tying a cord to the hind leg of a pig, and driving him before them into their pastures. They then observe, where he stops and begins to root: and digging there they are sure to find a truffle. So in pastures where there are earth nuts, though the roots are deep in the ground, and the leaves are quite gone, the swine will find them by their scent, and root only in the places where they grow.

Another instance of like nature we have in the PORPUS, anciently wrote *porc-pesce*, that is, *swine-fish*, which resembles the hog, both in the strength of his snout and in the manner of getting his food. For the stomach of one of these when dissected, was found full of sand-eels, which lie deep in the sand, and cannot be gotten, but by rooting and digging there.

That very action, for which we look upon swine as unclean creatures, namely wallowing in the mire, is designed by nature for a good end; not only to cool their bodies, which fair water would do as well, but also to suffocate and destroy fleas, lice, and other insects, which are troublesome and hurtful to them. For the same reason, poultry and divers other birds bask themselves in the dust in hot summer weather.

The *variety* of shape and colour observable in BEASTS, prevents any two from being exactly alike, as much as the human features distinguish mankind one from another. Wherefore then was this variety bestowed upon brutes? Are they at all sensible of such diversity? Are they the more happy, or more useful to one another for it? No. This variety then is doubtless intended for the sake of man, to prevent confusion, and decide and ascertain his property.

CHAPTER II.

OF BIRDS.

1. NO part of nature is destitute of inhabitants. The woods, the waters, the depths of the earth, have their respective tenants; while the yielding air, and those tracts where man never can ascend, are also passed through by multitudes of the most beautiful beings of the creation.

Every order of animals is fitted for its situation in life; but none more apparently than birds. Though they fall below beasts in the scale of nature, yet they hold the next rank, and far surpass fishes and insects, both in the structure of their bodies and in their sagacity.

The body of man presents the greatest variety: beasts less perfectly formed, discover their defects in the simplicity of their conformation: the mechanism of birds is yet less complex: fishes are furnished with fewer organs still; while insects, more imperfect than all, fill up the chasm between animal and vegetable nature. Of man, the most perfect animal, there are but three or four species; the kinds of beasts are more numerous; birds are more various still; fishes yet more; but insects afford an immense variety.

In all birds, except nocturnal ones, the head is smaller, and bears less proportion to the body than in beasts, that it may the more readily divide the air in flying. Their eyes also are more flat and depressed, and a circle of small plates of bone, placed scale-wise under the outer coat of the organ, encompasses the pupil on each side to strengthen and defend it from injuries. Besides this, birds have a kind of skin, called the nictitating membrane, with which, like a veil, they can at pleasure cover their eyes, though their eyelids continue open. This membrane serves also to wipe, cleanse, and probably to moisten its surface. The eyes, though they outwardly appear but small, yet each almost equals the brain; whereas in man the brain is more than twenty times larger than the eye.

Hence it follows, that the sense of SEEING in birds is infinitely superior to that of other animals. Indeed this piercing sight seems necessary to the creature's support and safety. Were it not so, from the rapidity of the bird's motion, it would be apt to strike against every object in its way; and it could scarcely find subsistence, unless it could discern its food from above with astonishing sagacity. A hawk, for instance, perceives a small bird at a distance, which neither men nor dogs could spy; and a kite, from an almost imperceptible height, darts down on its prey with the most unerring aim.

Granivorous birds, or such as live upon vegetables, have their intestines differently formed from those of the rapacious kind. Their gullet dilates just above the breast-bone, and forms itself into a pouch or bag, called the crop. This is replete with salival glands, which moisten and soften the food it contains. After the dry food of the bird has been macerated, it passes into the belly, where, instead of a soft, moist stomach, as in the rapacious kinds, it is ground between two pair of muscles, commonly called the gizzard, covered on the inside with a strong ridgy coat. These coats rubbing against each other, are capable of attenuating the hardest substances ; their action being often compared to that of the grinding teeth, in man and other animals.

Thus the organs of digestion are in a manner reversed in birds. Beasts grind their food with their teeth, and then passes into the stomach, where it is softened and digested. On the contrary, birds of this sort first soften it in the crop, and then it is ground and comminuted in the stomach or gizzard. Birds are all careful to pick sand, gravel, and other hard substances, not to grind their food, as has been supposed, but to prevent the too violent action of the coats of the stomach against each other.

To birds, the return of spring is the beginning of pleasure. Those vital spirits which seemed locked up during the winter, then begin to expand ; vegetables and insects supply abundance of food ; and the bird having more than a sufficiency for its own subsistence, is impelled to transfuse life as well as to maintain it. Those warblings which had been hushed during the colder seasons, now begin to animate the fields ; every grove and bush resounds with the challenge of anger, or the call of allurement. The delightful concert of the grove, which is so much admired by man, is no way studied for his amusement : it is the call of the male to the female ; his efforts to sooth her during the time of incubation : or a challenge between two males for the affections of some common favourite.

It is by this call that birds begin to pair at the approach of spring, and provide for the support of a future progeny. The loudest notes are usually from the male ; the hen expresses her consent, in a short interrupted twittering. Their compact holds with unbroken faith : most birds live with inviolable fidelity together ; and when one dies, the other is always seen to share the same fate soon after. We must look for it in our fields and in our forests, where nature continues in unadulterated simplicity ; where the number of males is generally equal to that of females. But the male of all wild birds is as happy in the young brood as the female. They both seem, at this season, transported with pleasure : every action testifies their tender solicitude.

But previous to laying, the work of nestling becomes the common care: and this is performed with no small degree of assiduity. It has been asserted, that birds of one kind always make their nests in the same manner, and of the same materials; but the truth is, they vary this as the materials, places, or climates, differ. The red-breast, in some parts of England, makes its nest with oak leaves, where they are in plenty, and in other parts with moss and hair. Some birds, that with us make a very warm nest, are less solicitous in the warm climates. In general, however, every species of birds have a peculiar architecture of its own; and this adapted to the number of eggs, the temperature of the climate, or the heat of the animal's body. Where the eggs are numerous, the nest is warm, that the animal's heat may be equally diffused to them all. Thus the wren, and all the small birds make their nests very warm; for having many eggs, it is requisite to distribute warmth to them all: on the contrary, the plover, that has but two eggs, the eagle, and the crow, are not so solicitous in this respect, as their bodies are capable of being applied to the small number upon which they sit.

Nothing can exceed the patience of birds while hatching; neither hunger, nor danger, can drive them from the nest. They are fat upon beginning to sit, yet before incubation is over, are usually wasted to skin and bone. Indeed ravens and crows, while the females are sitting, take care to provide them with food in abundance. But it is different with most of the smaller kinds: during the whole time the male sits near his mate upon some tree, and sooths her by his singing; and often when she is tired takes her place, and patiently continues on the nest till she returns.

So great is the power of instinct in these animals, that they continue almost passive under its influence. Yet, at the same time, the hen, that has all this seeming ingenuity in other respects, is without the least glimmering of common sense: she mistakes a piece of chalk for an egg, and sets upon it in the same manner; she is insensible of any increase or diminution in the number of those she lays; she does not distinguish between her own and those of another species; and when the birth appears of never so different a bird, will cherish it for her own.

As the principle which acts in these animals cannot be termed reason, so when we call it instinct, we mean something of which we have no knowledge. It appears to me the immediate direction of Providence; and such an operation of the Supreme Being as that which determines all the portions of matter to their proper centres.

While the young are yet unfledged, the old one takes care to provide them with a regular supply: when the family is fully plumed, and capable of avoiding danger by flight, they are then led forth, when

the weather is fine, and taught the paternal art of providing for their subsistence. They are led to the places where their food lies; they are shewn the method of discovering or carrying it away; and then led back to the nest, for a day or two longer. At length, when they are qualified to shift for themselves, the old one takes them abroad, and leading them to the accustomed places, forsakes them for the last time; and all connection is at an end.

Birds in general, though they have so much to fear from man and each other, are seldom scared from their usual haunts. The greatest number remain contented, where they have been bred. The rook, if undisturbed, never desires to leave his native grove; the black bird still frequents its accustomed hedge; and the red-breast, though seemingly mild, claims a certain district, from whence he seldom moves, but drives out every one of the same species from thence without pity. They are excited to migrations by no other motives, but those of fear, climate or hunger. It is from one of these motives, that birds of passage, every year, forsake us for some time; and make their regular returns. The cause of their retreat is, either scarcity of food, or the want of an asylum from man, during the time of courtship, and bringing up their young. Thus the starling, at Sweden, at the approach of winter, finding subsistence no longer, descends into Germany; and the hen-chaffinches of the same country are seen to fly every year through Holland, to pass their winter in a milder climate. Others prepare for longer journies. Thus the quails, in spring, forsake the heats of Africa, for the milder sun of Europe; and when they have passed the summer with us, steer their flight to enjoy, in Egypt, the temperate air. This with them seems a preconcerted undertaking. They unite together in some open place, for some days before their departure, and, by an odd kind of chattering, seem to debate on the method to proceed. Then they all take flight together, and often in such numbers, that, to mariners at sea, they seem like a cloud upon the horizon. The strongest and by far the greatest number, make good their intention; but many there are, who grow weary in the way, and drop down into the sea, and sometimes upon the decks of ships.

Of the vast quantity of water-fowl, that frequent our shores, few are known to breed here. The cause that urges them to leave us seems to be, not merely the want of food, but the desire of a secure retreat. Our country is too populous for birds so shy, as the greatest number of these are. When great part of our island was an uncultivated tract of woods and marshes, many species of birds, which now migrate, remained with us the whole year. The great heron, and the crane, that have now forsaken this country, in former times bred familiarly in our marshes. Their nests, like those of most

cloven footed water fowl, were built on the ground, and exposed to every invader. But as rural economy increased, these animals were more and more disturbed. Once they had little to fear, as the surrounding marsh defended them from all the carnivorous surrounding quadrupeds, and their own strength from birds of prey; but by a long series of alarms, they have, at length, been obliged to seek, during the summer, some lonely habitation, at a safe distance from every destroyer.

Of the numerous tribes of the duck kind, we know of no more than five that breed here. The rest contribute to form that amazing multitude of water fowl which annually repair to the dreary lakes and deserts of Lapland, from the more southern countries of Europe. In those solitary retreats, they perform the duties of incubation and nutrition in full security. There are few of this kind that may not be traced to the northern deserts; to countries of lakes, rivers, swamps and mountains, covered with thick and gloomy forests. In those regions, from the thickness of the forests, the ground remains moist and penetrable during the summer season; the woodcock, the snipe, and other slender-billed birds, can there feed at ease; while the web-footed birds find more than sufficient food from the number of insects, which swarm to an incredible degree. The days there are long; and the beautiful nights afford them every opportunity of collecting so minute a food.

2. Birds have feathers which they expand in order to fly; the fine branches of which lie so close together, that little air can insinuate itself between them. Now when the column of air on which a body rests is specifically heavier than the body, it remains suspended in the air; if it be lighter, the body sinks. Hence, the larger space a body circumscribes, the more easily does the air sustain it. Consequently the same bird which sinks when the wings are closed, is sustained when they are expanded. To this also the motion of the wings contributes: as a body while moving swiftly, will swim in water, which immediately sinks, if that motion ceases. And so do the feathers, with which their bodies are clothed, which increase their bulk, but not their weight in the same proportion.

The parts of birds chiefly concerned in flying, are the wings and the tail. By the first, the bird sustains and wafts himself along. By the second he is enabled to keep his body steady and upright, particularly in ascending and descending. It is by the largeness and strength of the pectoral muscles, that they are qualified for flying. In men these are scarce a seventeenth part of the muscles of the body. In birds they considerably outweigh all the other muscles together.—And this circumstance alone, the want of suitable muscles, makes all human attempts to fly, void and vain.

Nevertheless the art of flying has been seriously attempted by many, in various ages, particularly in the time of our famous friar Bacon, who lived about 500 years since, and whom his excellent works shew to have been a rare chemist, an excellent nathematician, a knowing mechanic, and a most accomplished experimental philosopher. Yet even *he* believed the art of flying possible, and says, he himself knew how to make an engine, in which a man sitting, might be able to convey himself through the air, like a bird. Nay he affirms, that there was then another person, who had actually tried it with success.

In flying, the bird first bends his legs and leaps from the ground; then opens the joint of his wings, so as to make a right line, perpendicular to the sides of his body. Being now raised, and strongly vibrating his wings, the air re-acts, as much as it is acted upon, and so protrudes his whole body. But in recovering his wing for fresh strokes, it has a great resistance to overcome. To elude this, the bony part of the wing, into which the feathers are inserted, moves sideways with its sharp end foremost, and the feathers follow it like a flag.

All birds have near their tail a little bag, which contains oil, to moisten their feathers. Geese have two glands for the secretion of this; other birds have only one. In this are divers little cells ending in two or three large ones, lying under the nipple of the oil bag. This nipple is perforated, and being prest by the bird's bill, emits its oil.

In all birds that fly much, the wings are placed in the very best manner, to balance their bodies in the air, and to give as swift a progression as they are severally capable of. Otherwise they would reel and fly unsteadily; as we see they do if we destroy the equipoise, by cutting one of their wings.

And what nicety may we observe, in a part no more considerable, than the vanes of the flag-feathers of the wing!—1. The edges of the exterior or narrow vanes bend downward, but the interior, wider vanes, upward. By this means they catch hold and lie close to each other, when the wing is spread; that not one feather may miss its full force and impulse upon the air. 2. Equal nicety is observed in the very sloping the tips of the flag-feathers: the interior vanes are neatly sloped away to a point, toward the outward part of the wing. The exterior, (at least in many birds) are sloped toward the body. And in the middle of the wing, the vanes being equal, are but little sloped, so that the wing whether open or shut is as neatly sloped as if constantly trimmed with a pair of scissars.

The vane consists not of one continued membrane, because if once broke, it would not easily be repaired: but of many laminæ, which

are thin, stiff, and something resembling a thin quill. Toward the shaft of the feather (especially in the flag-feathers of the wing) these laminæ are broad and of a semi-circular form, which serves for strength, and for shutting them close together, when impulses are made on the air. Toward the outward part of the vane, they grow slender and taper. On their under side they are thin and smooth; but their upper, outer edge is parted into two hairy edges.

As curiously made are the feathers in the wing, and no less curiously placed, exactly according to their several lengths and strength; and these again are lined, faced, and guarded with covers and secondary feathers, to keep the air from passing through, and so eluding the impulse.

How admirably wrought are the bones of the wing! very strong, but light withal; the joints, which open, shut, and move as occasion is; and the various muscles, all suited to the motions which they minister to.

Next to the parts for flight, let us view the legs and feet, which minister to their other motions; both made light, for their easier passage through the air; and the latter, some with membranes for swimming, some without, for steady going, for perching, for catching and holding their prey, or for hanging by the heels to gather their food: the legs, all curved, for their easy perching or roosting, as also to help them upon their wings, in taking their flight. In some they are long, for wading and searching the waters: in others, if need be, remarkably short. And how wisely are they placed! In all, somewhat out of the centre of the body's gravity; but in such as swim, more than in others, for the better rowing their bodies: as also to help them in diving.

Geese and ducks, their bodies being made for swimming, have their wings too placed out of the centre of gravity, nearer the head; but the extending the neck and head in flight, balances the body upon the wings; which is another excellent use, beside searching for food, of the long neck of these birds.

But in the heron, whose head and long neck, although tucked up in flight, overbalances the hinder part of the body, the long legs are extended, both to counterpoise the body, and to supply what is wanting in the tail.

It has been supposed, that the flying of birds is analogous to the rowing of vessels. But it is a motion of quite a different kind. Oars are struck toward the stern: whereas birds do not vibrate their wings toward the tail, but waft them downward. Nor does the tail cut the air (as the rudder does the water) at right angles, but horizontally. It likewise keeps the same situation, which way soever the bird turns.

It is not therefore by the tail, that most birds turn to the right hand or the left, but by the wings. They turn to the right, by beating the air with the left wing alone toward the tail: to the left, by beating it with the right wing. Thus Pigeons* changing their course toward the left, labour with the right wing, scarcely stirring the other.

Birds with long necks have another way of altering their course, by only inclining their head or neck this and that way.

Birds rarely fly up or down perpendicularly, but rather in a crooked line. In ascending directly, the natural and artificial tendency would counteract each other. In descending directly, both would concur, and endanger too precipitate a motion.

Only the hawk stoops directly to seize its prey: whereas other birds in descending, retard the motion by keeping their wings expanded, and at the same time stretching out their feet and legs.

There is no flying animal, but has feet as well as wings; because there is no food, or at least not sufficient for them, to be had always in the air. But if there were, yet such birds could take no rest; for having no feet, they could not perch upon trees. And if they alighted on the ground, they could not raise themselves again: which birds that have short feet can hardly do. Beside, they would want means of breeding, having no way to lay their eggs, to sit, hatch, or brood their young.

Before we conclude this head, it may be observed, that all the parts of birds are fitted for the use of flying. First, as the muscles of the wings are peculiarly strong, so the under side of them is made concave, and the upper convex, that they may be the more easily lifted up, and more strongly strike the air. Then the trunk of their body somewhat resembles the hull of a ship; the head, the prow; which is generally small, that it may the more readily cut the air, and make way for the body. Add to this, that the bodies of birds are small in comparison of beasts, that they may be more easily supported by the air. And they are not only small, but of a broad figure, that they may be buoyed up the better. They are also hollow and light: yea, their very bones are light. For even those of the legs and

*It is a remarkable use which is made of pigeons, in the eastern countries. They are trained up in Turkey and Persia, to carry expresses; being first used to short flights, afterwards to longer, till at length they will return from the farthest part of the kingdom. Yea, if they are brought hood winked twenty or thirty miles, nay, sixty or a hundred, they will find their way in a very little time, to the place where they were bred. Every bashaw has a basket of the pigeons bred at the Seraglio; one of which he despatches thither on any emergent occasion, with letters braced under her wings. This proves a more speedy method, as well as safer, than any other. For one of these birds will carry a letter from Babylon to Aleppo, which is thirty days journey, in forty-eight hours.

wings have ample cavities: by this means also they become rigid and stiff: it being demonstrable, that a hollow body is more stiff and inflexible, than a solid one of equal substance. The shafts also of the feathers are either empty, or filled with a light and spongy matter. And their webs consist of two rows of contiguous filaments furnished all along with hooks on each side, whereby catching hold of one another they stick fast together.

As to their tails, although it is true, as was observed, that all birds whose tails are pointed and end in a right line, turn themselves by their wings and not their tails, yet in those that have forked tails it is otherwise. Thus it is manifest to sight, that the forked tail Kite, by turning her train sideways, raising one horn and depressing the other, turns her whole body; and doubtless the tail has the same use in swallows, who have all forked tails, and make more sudden turns in the air than any other bird.

To lighten birds still farther, they have large membranes extending to the bottom of their bellies, into which the air is received, where, by the heat of the body it is expanded into twice or thrice the dimensions of the external air. And this they can either compress by the muscles of the abdomen, or expire more or less, in order to their descending swifter or slower, in what degree they please.

3. As to the brain of birds, whereas in men the corticle part of the brain is outermost, in birds it is innermost, and the membrane that covers the upper ventricle is medullary. The ventricles likewise are situated above, near the upper part of the skull.

Perhaps before we proceed, it may be well to premise one general observation, that the structure of birds is in many respects different from those both of men and beasts; having several parts which these want, and wanting others which they have. Besides, there are great variations in the contrivance of parts which are common to both: all wisely adapted to their different conditions and manner of life.

Parts peculiar to birds are, 1. The bill. 2. The membrane to draw over the eyes. 3. Feathers and wings. The parts wanting in birds are, 1. Teeth and lips. 2. The bladder, which they do not need, as they drink no more than just to moisten their food. Variations in the parts of birds from those of men and beasts, are, 1. In the ear, which is of a very peculiar make. 2. In the division of the aorta. 3. In the spinal marrow, which is divided into two in the middle of the back. 4. In the bones, which are all hollow. 5. In the heart, which has a fleshy valve at the mouth of the vena cava. 6. In the lungs, which are strongly joined to the back, for the greater conveniency of flight. 7. In the stomach: birds have two or more, to supply the want of chewing. 8. In the legs and feet. 9. In their

tails. 10. In their pectoral muscles, which are the strongest of all, whereas in man the crural muscles are the strongest. 11. In the brain, as was before observed. 12. In the bronchia, which extends to the very bottom of the abdomen, so as to contain a large quantity of air. 13. In the ovaries, which in birds are single and fastened on their back.

4. The ears of birds differ much from those both of men and beasts. There is almost a direct passage from ear to ear: so that if the drum be picked in either ear, water poured in at one ear, will run out at the other. And what is still more remarkable, they have a small winding passage, that opens into a large cavity, running betwixt two skulls, and passes all around the head. The upper of these skulls is supported by many hundreds of small, thread-like pillars: which have another use also, to break their sound and hinder its making a confused echo.

This passage between the two skulls is much larger in singing birds than in others. So that a person who has been shewn this, may hereafter know them from all others.

The other organs of sense are nearly the same in birds as in other animals. Only there is a difference in the organ of smell. The nostrils lie on each side of the beak, in the inner part whereof, beside the tube which reaches to the lungs, there are little tubes, continued from the membranes and substance of the brain. And these seem to be the organ of smell. Only two nerves pass through the *os cribrosum* to the beak: lest if there were more perforations, as in other animals, too much air might flow into the brain.

The bill of birds is peculiarly remarkable. In the first place, it is neatly shaped for piercing the air. In the next, it is hard and horny, to supply the want of teeth, and also in some measure, of a hand. Its hooked form is of great use to rapacious birds, in catching and holding their prey; and to others, in climbing, and in taking and comminuting their food.* Its extraordinary length and slenderness is of use to some, to search for their food in moorish places:† as its length and breadth is to others, to hunt and search in muddy places.‡

* Parrots have their bills nicely adapted to these services, being hooked, for climbing and reaching what they want, and the lower jaw so exactly fitted to the hook of the upper, that it will break the food, as other creatures do with their teeth.

† As the woodcocks and snipes, who hunt for worms in moorish ground, and likewise suck the unctuous humour out of the earth. So also the bills of curlews, and other sea fowl, are very long, to enable them to hunt for worms, &c. in the sands.

‡ Ducks, geese and divers other species of birds, have bills both long and broad, whereby they are enabled to quaffer in the water or mud, till they find their food.

The contrary form, a thick, short and sharped edged bill, is as useful to all other birds, who must husk the grain they swallow. But it would be endless to reckon up all the shapes and commodious mechanism of all: the sharpness and strength of those that have occasion to perforate woods and shells;* the slenderness and neatness of such as pick up small insects; the cross form of such as break up fruits;† the compressed‡ form of others, with many other curious forms, all suited to the occasions of the several species.

In the flat-billed birds, as ducks, there are three pair of nerves, which come down between the eyes in the upper bill, whereby they are enabled to smell and find out their food in the mire or water. The like have been observed in several round-billed birds, but so small as to be scarce discernible. Only in the rook they are discernible enough; and it is remarkable that these, more than any other round-billed birds, grope for their meat in cow-dung, and the like.

5. Of their LUNGS it is observable, that they are not only larger in proportion than those of beasts, but they admit the air, both above and beneath, by which means they become far lighter.

A duck is furnished with a peculiar structure of vessels, which enables it to live some time under water. Yet she cannot live without air. One that was put into the air-pump, and the air exhausted, seemed to bear it better for a few moments than any other fowl. But in less than two minutes her head fell down, and she appeared dying, till revived by letting in the air.

A young callow duck, being tried in the same manner, was near death in less than two minutes. It is observable, both of them swelled extremely, on pumping out the air. It not being intended, that water-fowl should live in an exceeding rarified air, but only continue under water, they are qualified for this, but not at all for the other.

* The green woodspike, and all woodpeckers have strong and sharp bills, curiously made for digging wood. An even ridge runs along to the top of the green woodpecker's bill, as if an artist had designed it at once for strength and neatness.

Woodpeckers have also a tongue, ending in a sharp, bony rib, dented on each side, which they can at pleasure shoot out to a great length, and thrust into the holes, clefts and crannies of trees. They strike them likewise into ant hills, and fetch out the ants and their eggs. Moreover, they have short, but strong legs, and their toes stand two forward, two backward; a disposition which is particularly convenient for the climbing of trees. In this they are likewise assisted by the uncommon stiffness of the feathers of their tails, and by their bending downward whereby they are fitted to serve them as props to lean on.

† The cross-bill, whose bill is thick and strong, with the tips crossing each other, readily breaks open fir cones and other fruits, to come at and feed on the kernels. And undoubtedly the crossing of the bill was designed for this very service.

‡ The sea-pye has a long, sharp, narrow bill, compressed sideways, and every way adapted to the raising limpets from the rocks, which are its chief, if not only food.

Yet that ducks can live almost any where, we may learn from the blind ducks of Zerchintzer lake, in Carniola, a territory of Austria. This communicates with another lake under ground in the mountains of Savornick, and fills or empties itself according to the fulness or emptiness of that. The waters of the upper lake, when it empties, runs off by large holes in the bottom. The ducks which are very plentiful in the water, are often carried down with it into the subterraneous lake. In this many of them undoubtedly perish; yet some remain alive. But they loose their sight and feathers: and at the next filling of the upper lake, both they and vast numbers of fish are thrown up with the water. They make a strange appearance in their naked state: and for want of sight are easily caught. In about a fortnight they recover their sight and their feathers, and are then as big as common wild ducks. At their first coming up, their stomachs are full of small fishes, and something resembling weeds. It seems, therefore, they were not quite blind, when in their dark habitation, but could see by that small quantity of light, to search for and find their food.

Nor is it in this lake only that these ducks are found. They are frequently thrown up, after great rains, at a hole in a mountain, near the town of Laon, in the isle of France. The water then gushing out with great violence, brings these blind and bald creatures with it. And their frequency and cheapness, from the vast quantities which are thrown out, make them esteemed no variety.

The bodies of duckers or loons are admirably fitted for diving: being covered with a thick plumage, and the surface of it so smooth, that the water cannot penetrate it. Hereby their bodies are defended from the cold, the water being kept at a distance; and are so poised, that by a slight impulse, they easily ascend in it. Again, their feet are situate in the hindmost part of the body, so that shooting them backward and striking the water upwards, they plunge themselves down with great ease, and move forward therein. Their legs also are made flat and broad, and their feet cloven into toes, with appendant membranes on each side. By this configuration they easily cut the water, and are drawn forward, to take their stroke backward; and by this, their feet being moved to the right or left, serve them as a rudder to turn under water. How they rise above water is not determined: whether by their natural lightness, or by striking against the bottom, in the manner of a leap, or by some peculiar motion of the legs. That they dive to the bottom is undeniable. For in the stomachs, both of the greater and lesser kind, we find much grass and other weeds; and in the lesser kind, little else. Yet both prey upon fish; and their bills are straight and sharp, for the easier striking their prey.

It is likewise remarkable, that whereas in other animals the lungs are loose and have much play, in all birds they adhere to the thorax, and have little play. This is a good provision for their steady flight. Also they want the diaphragm, and instead thereof have divers large bladders, made of thin, transparent membranes, with pretty large holes, out of one into the other. These membranes serve for braces to the viscera, as well as to contain air. Toward the upper part, each lobe of the lungs is perforated in two places with large perforations: whereof one is toward the outer, the other toward the inner part of the lobe. Through these perforations the air has a passage into the forementioned bladders; so that by blowing into the windpipe, the lungs are raised, and the whole belly blown up. This doubtless is a means to make them more or less buoyant, as they take in more or less air: and so answers the design of the air bladder in fishes.

In general we may observe, whatever is peculiar in the wings, bills, and every other part of birds, on a close inspection will be found exactly suited to their wants. They are a set of implements nicely proportioned to their manner of life. To instance in a few, sparrows and most small birds are supported by the little grains they find up and down. They have no effort to make, to obtain their food, or break it in pieces, and therefore have a small bill, as well as short necks and legs, which are sufficient for their purposes. But the woodcock, snipe, curlew, and many other birds, seek their food deep in the earth or slime. Therefore they are provided with a long neck and bill, and with these they dig and search and want for nothing. The woodpecker, who lives in a quite different manner, is as differently formed. His bill is very long, solid, and strong: his tongue is sharp, and extremely long; beside which, it is armed with little points, and covered with glue toward the extremity. He has short legs, two talons before, two behind, and all very crooked. All this equipage suits his manner of living. His food is worms or insects, that live in the heart of branches of trees, or under the bark of old wood; frequently they are sunk very deep, under the bark of large billets. The woodpecker has hooked claws, to grasp these branches; and a strong and pointed bill, to find out by darting it up and down, what parts of them are rotten. When he has found out these, he with his bill, shatters the bark and wood. He then sends forth a loud whistling cry, into the cavity, to alarm the insects and put them in motion. Next he darts in his tongue, and by the small points which arise out of it, and the glue that covers it, draws out whatever is lodged there.

The HERON, on the contrary, mounts aloft. His legs and thighs are very long, and bare of feathers. He has a great length of neck, and

an enormous bill, very sharp and jagged at the end. What reason can be assigned for a figure, which at first sight seems so extravagant? He feeds on frogs and small shell-fish, as well as other fish, which he finds in fens, or bogs, or near the shores of rivers. He wants no feathers on his thighs to walk through water and slime: but he needs very long legs, to run in the water, along the shores, whither the fishes resort for their food. A long neck and bill qualify him for pursuing and seizing his prey at some distance: and the jaggs of his bill enable him to hold the fish, which would otherwise slide away. In fine, his large wings, which seem incommodious to a bird of so small a body, are absolutely needful for his making so great movements in the air, and conveying such burdens to his nest, which is frequently two or three leagues distant from the place where he fishes.

The imperfections, therefore, which we imagine we discover, in this, as in many other animals, in reality belong only to our own understanding, and all our censures of the works of nature, are, in truth, only so many indications of our own ignorance.

6. The stomach, especially of granivorous birds, is of a peculiar structure. First, there is a glandulous receptacle, wherein the grains are kept for some time. They are then received into another stomach, consisting of two muscles, and a callous membrane. One of these moves obliquely downward, and the other upward. Hereby the shell of the grain is broke, and the meal expressed and mixt with proper juices. The aliments thus prepared, fall into the bottom of the stomach, where they are purged again from the refuse: to which end that part is a little raised, that the corn may not pass out too soon. There is also a partition, which divides what is already digested from the rest.

As birds have no bladder, in the room of urine, a whitish excrement is discharged fron the kidneys into the rectum.

7. The generation of birds is not well known. In the ovary, placed between the liver and the back-bone, a great number of yolks are contained; one of which, when impregnated, passes through the oviduct into the womb, where it receives the white and the shell, and remains till it comes to its full size. The parent then broods over it, till the young being gradually formed, perfected, and quickened, bursts the shell.

Under the shell of an egg lies the common membrane, adhering closely to it, except at the bigger end, where a little space is left between them. This membrane contains two whites, each enclosed in its own membrane. In the middle of the inner white is the yolk, enclosed likewise in a separate cover. The outer white is oval, the inner round, as is the yolk, and of a more viscid substance.

At each end is a *chalaza*, a white, dense body, consisting of three little globules, like grains of hail, (so the word signifies) all joined together. These serve both to knit the several membranes together, and to keep the liquors in their proper places and position.

About the middle of the small end of the yolk, is a little yellowish bladder, like a vetch, called the *cicatricula*, or EYE of the egg. This contains a humour, in and out of which the young bird is generated. The white serves it for food, till it becomes big; then the yolk, and likewise after it is hatched. For even then a good part of the yolk is lodged in its belly, as in a store-house, and being conveyed thence by the intestinal duct into the bowels, serves it instead of milk.

An egg, improperly so called, is that of the whole whereof the animal is formed. Such are the eggs of flies. Proper eggs, when excluded, need no external nutriment. Of proper eggs, some are perfect, that is, have all the parts above described, while in the ovary or womb: some imperfect, which have them not, till after they are excluded; as those of fishes, which assume a white in the water.

An egg not impregnated by the male, will never breed young, but always putrify. One impregnated contains the rudiments of the bird, even before incubation. By the microscope we see the plain *carina* or spine of it swimming in the middle of the *cicatricula*, consisting of fine, white threads, which incubation gradually perfects.

The air bag is very small in a new laid egg, but becomes larger when the egg is kept. The yolk is specifically heavier than the white. Hence its smaller end is always uppermost, in all positions of the egg.

After incubation, the air-bag gradually extends, till near the hatching; it takes up a third of the egg. By incubation the white becomes thinner and more turbid, especially near the air-bag, where it is first consumed. Then it lessens towards the sharp end of the egg, till nothing is left, but a white, chalky substance. The white of an impregnated egg is as sweet all the time of incubation as that of a new laid egg. They are only unimpregnated eggs, vulgarly called wind eggs, which putrify and stink.

The yolk also remains fresh and uncorrupted all the time of the incubation. It is deprest in the middle, as the chick grows, and is soon brought into a form, not much unlike that of a horse-shoe, in the middle of which the chick lies.

Not long before the chick is hatched, the whole yolk is taken into the abdomen.

The eye or tread, in which the chick lies, is soon enlarged by incubation, and rises to the upper part of the egg. The heart and umbilical vessels, are some of the first parts which we are able to distinguish.

The embryo is seen at first like a small worm. Then its carina or spine appears, with the large prominences that afterward shew themselves to be the brain and eyes. The other bowels seem hanging from the spine. Then the chasm of the mouth is discovered.—The extremities sprout out. The bowels are gradually covered with the teguments. At last the beak, nails, and feathers are seen. When all its parts are formed, the chick is always found lying on in its side, with its neck bent forward, the head covered with the upper wing, and the beak placed between the thighs.

The birds which nourish their young, have commonly very few. On the contrary, those whose young feed themselves when they first see the day, have sometimes eighteen or twenty at a brood. This prudence could only spring from Him, who regulates all things to the best advantage. Were those who provide for their young to have so numerous a brood, both the parents would be slaves, and yet the young but ill accommodated. Whereas the mother, who only marches at their head, without nourishing them, can conduct twenty as well as four.

But when they first make their appearance, what care do the parents take, till their young can subsist without them? Of those that feed their young, the linnet and the nightingale then labour like the rest. Sometimes one parent goes in quest of provisions, sometimes the other, and sometimes both. They are up before the sun. And the food they have procured, they distribute with great equality, giving each a portion in its turn, before ever they feed one bird twice.

And this tenderness for their offspring is so strong, as even to change their natural disposition. Follow the hen when she is the parent of a family, and she is no longer the same creature. She is no longer ravenous and insatiable. If she finds but a grain of corn or a crumb of bread, she never touches it herself, but calls her troop, by a note they well understand, and divides it among them. She is no longer timorous, but at the head of her young, will spring even at the stoutest dog.

When the turkey-hen appears at the head of her young, she sometimes utters a mournful cry, and they immediately run under bushes, furze or whatever presents itself. She looks upward, and repeats her cry: which is occasioned by her seeing a bird of prey, though so distant, that he appears unto us, only as a dark point under the clouds. But he no sooner disappears, than she utters another cry, which revives all her brood. They run to her, flutter their wings, and shew all the tokens of joy. Now, who apprizes her of an enemy, that never yet committed any act of hostility in the country? And how is she able to discover him, when at so great a distance?

How are her family instructed to understand her different cries, and regulate their behaviour accordingly? What wonders are these which are daily obvious to our view, though we treat them with inattention!

An amazing degree of natural instinct, or understanding, God has imparted to birds of passage. They fly in troops often in the form of a wedge, with the point foremost. They steer their course through unknown regions, without either guide or compass. And they are peculiarly accommodated for their flight, by the structure of their parts.

In the act of migration, it is highly remarkable, 1. That they know, as the scripture speaks, their appointed times, when to come and when to go. Appointed by whom? Surely by the great Creator, who has imprinted on their nature an inclination, at such a time to fly from a place that would obstruct their generation, or not afford food for them and their young, and betake themselves, to another place, which will afford all that is wanting.

It is highly remarkable, 2. That they know whither to go, and which way to steer their course! That they should be directed yearly to the same place, perhaps to a little island, as the Basse in Edinburgh-Frith! How came land birds to venture over a vast ocean, of which they can see no end? And how do they steer their course aright to their several quarters, which before the compass was invented, man himself was not able to do? They could not possibly see them at that distance. Or if they could, what should teach or persuade them that that land is more proper for their purpose than this? That Britain, for instance, should afford them better accommodations, than Egypt, than the Canaries, than Spain, or any other of the intermediate places?

But it has been commonly supposed that several birds are of this number, because they disappear in winter, which really are not: cuckoos, for instance, and swallows; for neither of these ever cross the seas. Cuckoos lodge all the winter in hollow trees, or other warm and convenient cavities. And swallows have been found in vast quantities, clung together in a lump, like swarms of bees, but utterly cold and senseless, (even in ponds that have been cleaned out,) hanging under the water.

I know not how we can doubt of this fact, that swallows have been found in winter, under water, clung together, attested by men of unquestionable veracity. And yet others affirm, that they have seen flights of swallows crossing the sea in autumn. The truth seems to be this. There are some species of swallows, which seek a warmer climate at the approach of winter, while others remain here in a temporary death, like the flies on which they feed.

They have in Virginia, a martin, like ours, only larger, which builds in the same manner. Colonel Bacon observed for several years, that they constantly came thither upon the tenth of March. Two of them always appeared a day or two before, hovering in the air. Then they went away, and speedily returned with the whole flock.

The following seems to be a very rational account of most of those that are really birds of passage.

When, by the approach of our winter, their food fails, birds of passage are taught by instinct to seek it elsewhere. Want of food seems to be the chief reason for their migration. The length of their wings enables them to catch the flying insects, with which the air is stored during the warm months. And most summer birds of passage, feed on the wing upon such insects as are seen no more when winter comes. If it be considered, how much of the globe still remains unknown, it is no wonder we are not yet acquainted with the places to which they retire. Probably they lie nearly in the same latitude in the southern hemisphere, as those from whence they depart.

As swallows cannot bear so much cold, as some other birds of passage, they are constrained to visit us somewhat later, and to depart somewhat sooner. Some birds stay a month after them. Probably many of them perform long journies chiefly in the night. Lying on the deck of a sloop, on the north side of Cuba, I and the company with me heard, three nights successively, flights of rice birds, their notes being plainly distinguishable, passing over our heads, northerly, which is their direct way from the southern continent of America, from whence they go yearly when the rice begins to ripen, and after growing fat, return back.

There are also winter birds of passage, which arrive here in autumn and go away in the spring, namely, the fieldfare, redwing, woodcock and snipe. But the two latter sometimes spend the whole year here. Whereas the two former constantly at the approach of summer, retire to more northern climates, where they breed and remain till, at the return of winter, they return to us again.

The winter food of these birds being berries and haws, which are far more plentiful here than in more northern regions, this is one reason of their coming over: but the principal is, the severity of the weather in those climates, which nature teaches them to exchange, for such as are more temperate. But why do they depart from us in spring? This still remains among the secrets of nature.

Beside these SUMMER and WINTER birds, there are others which come periodically to certain places, for the sake of some sort of food, which their own country is destitute of. These quickly depart, and are

seen no more till that time twelve-month. Such are the RICE-BIRD and BLUE-WING of Carolina.

But above half a century passed, from the time of cultivating rice and wheat in Carolina and Virginia, before these foreign birds made their appearance there. The WHEAT-BIRDS now come annually to Virginia, when the wheat ripens, and have come every year, since their first appearance, in numerous flights.

The species of birds already known, amount to about eight hundred. Linnæus divides them into six classes; namely, into birds of the RAPACIOUS KIND, birds of the PIE KIND, birds of the POULTRY KIND, birds of the SPARROW KIND, birds of the DUCK KIND, and birds of the CRANE KIND. The four first comprehend the kinds of land birds; the two last, those that belong to the water.

In beginning with the feathered tribe, the OSTRICH seems to unite the class of beasts and of birds in itself. While it has the general outlines and properties of a bird, it retains many of the marks of a beast. In appearance it resembles the camel, and is almost as tall; it is covered with a plumage that resembles hair much more than feathers, and its internal parts bear as near a similitude to those of the beast as of the bird creation. It may be considered, therefore, as an animal made to fill up that chasm in nature which separates one class of beings from another. It is usually seven feet high, from the top of the head to the ground. The external eye is like that of a man, the upper eye lid being adorned with eye-lashes, which are longer than those on the lid below.

They inhabit the most solitary deserts, where there are few vegetables, and where the rain never comes. The Arabians assert, that the ostrich never drinks; and the place of its habitation confirms the assertion. In these regions, ostriches are seen in large flocks, which to the distant spectator appear like a regiment of cavalry. The ostrich is of all other animals the most voracious.* It will devour leather, hair, grass, iron, stones, or any thing that is given. But

* The Cassowary belongs to the same order of stratheo. It is nearly the size of the ostrich, but exceeds it in strength and voraciousness. Its stomach is reckoned to contain the most powerful dissolvent juices of any animal in creation.—It has been observed to swallow indiscriminately, pieces of brick, rocks, iron, copper, and any thing that came within its way. Some sailors threw their jacknives, which they carried about them, to one, which swallowed them, one after the other; they then threw their buckles, which it swallowed in the same manner; one of them at last threw his shoe, which instantly followed the buckles. They are a most singular and fearful looking bird; the legs of some of the largest, have measured nearly a yard from the belly to the ground. Like the ostrich, they cannot fly, but use their wings to assist them in running, and are so swift as to scorn the horse and his rider; the largest of this species was brought from New-Holland: they are very common about Port Jackson.

those substances which the coats of the stomach cannot soften, pass whole; so that hair, stones, and iron, are excluded in the form in which they were devoured.

In their native deserts, however, they live chiefly upon vegetables, where they lead an inoffensive and social life; the male, as Thevenot assures us, assorting with the female with connubial fidelity. They lay generally from forty to fifty eggs. It has been commonly reported, that the female deposits them in the sand; leaves them to be hatched by the heat of the climate, and then permits the young to shift for themselves. Very little of this, however, is true: no bird has a stronger affection for her young: none watches her eggs with greater assiduity. Indeed, in those hot climates, there is no necessity for the continual incubation of the female: but though the female forsakes her eggs by day, she carefully broods over them by night. Then they sit on their eggs like other birds, and the male and female take this office by turns. Nor do they forsake their young after they are excluded the shell. On the contrary, the young ones are not even able to walk for several days after they are hatched. During this time, the old ones are very assiduous in supplying them with grass, and very careful to defend them from danger; nay, they encounter every danger in their defence.

All land-birds of the rapacious kind, are furnished with a large head, and strong crooked beak, notched at the end, for the purpose of tearing their prey. They have strong, short legs, and sharp, crooked talons, for the purpose of seizing it. Their bodies are formed for war, being fibrous and muscular; and their wings for swiftness of flight, being well feathered and expansive. The sight of such as prey by day is astonishingly quick; and such as ravage by night, have their sight so fitted as to see objects in darkness. Thus formed for war, they lead a life of solitude. They inhabit, by choice, the most lonely places. They make their nests in the clefts of rocks, and in the highest and most inaccessible trees of the forest. Whenever they appear in the cultivated plain, it is only for the purposes of depredation: and they spread terror wherever they approach: all the variety of music, which but a moment before enlivened the grove, at their approach is at an end: lesser birds seek for safety, either by concealment or flight; and some are even driven to take protection with man, to avoid their less merciful pursuers.

It would indeed be fatal to all the smaller race of birds, if, as they are weaker than all, they were also pursued by all: but it is contrived wisely, that every order of carnivorous birds seek only for such as are of a size approaching their own. The eagle flies at the bustard or the pheasant, the sparrow-hawk at the thrush and the linnet. And nature has provided that each species should make war

only on such as are furnished with adequate means of escape. The smallest birds avoid their pursuers by the extreme agility, rather than the swiftness of their flight; for every order would soon be at an end, if the eagle, to its swiftness of wing, added the versatility of the sparrow.

Another circumstance which tends to render the tyranny of these animals more supportable, is, that they are less fruitful than other birds. Those of the larger kind seldom produce above four eggs, often but two: those of the smaller kinds, never above six or seven. Likewise the carnivorous kinds, only breed annually, and of consequence their fecundity is small.

8. The largest of birds is the CUNTOUR of Peru. The body is as big as that of a sheep. Its wings extended are fifteen or sixteen feet from point to point. It is never seen in forests, because it would not have room to fly, but frequents the seashore and the banks of rivers. Nature, to allay their fierceness, has denied them the talons given to eagles, though they are of the eagle-kind. However, their beak is strong enough to tear off the hide, and rip up the bowels of an ox.

What a blessing is it to mankind, that there are but few (just enough to keep up the species) of this monster in the feathered creation!* And into what can we resolve this, but the wise and over-ruling care of an adorable Providence?

In beasts the smallest animals are noxious, and loathsome; the smallest of birds are the most beautiful, innocent, and sportive. Of all those that flutter in the garden, or paint the landscape, the humming bird is the most delightful to look upon, and the most inoffensive.

Of this there are six or seven varieties, from the size of a small wren, down to that of a humblebee. An European could never have supposed a bird existing so very small, and yet completely furnished

* Some species of eagles are very formidable and destructive. They seize and carry away fawns, lambs, kids, and all kinds of game. Indeed it is very unsafe to leave infants where they frequent. There have been instances of their being carried off by them. Mr. Bruce in his travels in Abyssinia, gives an account of an eagle of surprising dimensions. It measured from wing to wing, 8 feet 4 inches. From the tip of his tail, to the point of his beak, when dead, 4 feet 7 inches. The thickness of his thigh was little less than 4 inches. It was extremely muscular, and covered with flesh. His middle claw was two and a half inches long, and extremely strong, the bill was three and a quarter inches long, and near 2 inches in breadth at the root. This amazing bird was of the species called the bald eagle. He was shot by a rifle ball at the top of mount Lamalmon, while attacking Mr. Bruce's company at dinner, allured by the smell of the meat; it threw the company into the utmost consternation, and absolutely succeeded in carrying off in its talons, a leg and shoulder of meat, from a wooden dish. But returning again to renew his depredations, he was fired upon and shot under the wing.

out with a bill, feathers wings and intestines, exactly resembling those of the largest kind. A bird not so big as the end of one's little finger, would probably be supposed but a creature of imagination, were it not seen in infinite numbers, and as frequent as butterflies in a summer's day, sporting in the fields of America, from flower to flower.

The smallest is about the size of a hazel-nut. The feathers on its wings and tail are black; but those on its body, and under its wings, are of a greenish brown, with a fine red cast or gloss, which no silk or velvet can imitate. It has a small crest on its head, green at the bottom, and as it were gilded at the top; and which sparkles in the sun like a little star in the middle of its forehead. The bill is black, straight, slender, and the length of a small pin.

As soon as the sun is risen, the humming-birds, of different kinds, are seen fluttering about the flowers, without ever lighting upon them. Their wings are in such rapid motion, that it is impossible to discern their colours, except by their glittering. They are never still, but continually in motion, visiting flower after flower: they are furnished with a forky tongue, that enters the cup of the flower, and extracts its nectared tribute. Upon this alone they subsist. The rapid motion of their wings brings out an humming sound, from whence they have their name.

The nests of these birds are not less curious than the rest: they are suspended in the air, at the points of the twigs of an orange, of a pomegranate, or of a citron tree. The female is the architect, while the male goes in quest of materials; such as cotton, fine moss, and fibres of vegetables. Of these materials a nest is composed, of about the size of a hen's egg cut in two, admirably contrived, and warmly lined with cotton. They lay two eggs at a time, about the size of small peas, and as white as snow, with here and there a yellow speck. The male and female sit upon the nest by turns: but the female takes to herself the greatest share. She seldom quits the nest, except a few minutes in the morning and evening when the dew is upon the flowers. The time of incubation continues twelve days; at the end of which the young ones appear, much about the size of a blue-bottle fly.

Father Labat's companion, in the mission to America, found the nest of a humming-bird, and took it in, at a time when the young ones were about fifteen or twenty days old; he placed them in a cage at his chamber window; but he was soon surprised to see the old ones, that came and fed their brood regularly every hour in the day. By these means they themselves soon grew so tame, that they seldom quitted the chamber; but without any constraint, came to live with their young ones.

All four have frequently come to perch upon their master's hand, chirruping as if they had been at liberty. He fed them with a fine clear paste, made of wine, biscuit and sugar. They thrust their tongues into this paste, till they were satisfied, and then fluttered and chirrupped about the room. I never beheld any thing more agreeable, continues he, than this lovely little family, that had taken possession of my companion's chamber, and that flew out and in just as they thought proper; but were ever attentive to the voice of their master when he called them. In this manner they lived with him above six months; but, at a time when he expected to see a new colony, he unfortunately forgot to tie up their cage to the ceiling at night, to preserve them from the rats, and he found they were devoured in the morning.

Even VULTURES are in Egypt of singular service. There are great flocks of them in the neighbourhood of Grand Cairo, which no person is permitted to destroy. The service they render the inhabitants, is the devouring the carron and filth of that great city, which might otherwise corrupt and putrify the air. They are commonly seen in company with the wild dogs of the country, tearing a carcase very deliberately together. This odd association produces no quarrels; the beasts and birds live amicably, and nothing but harmony subsists between them.

The wonder is still the greater, as both are extremely rapacious, and both lean and bony to a very great degree, having no great plenty, even of the wretched food on which they subsist.

In America, wherever the hunters go, who pursue beasts for their skins, these birds pursue them. They still keep hovering at a little distance: and when they see the beast flayed and abandoned, they call out to each other, pour down upon the carcase, and in an instant, pick its bones as clean as if they had been scraped by a knife.

ROOKS keep together in pairs; and when the offices of courtship are over, prepare for making their nests and laying. The old inhabitants of the place are already provided; the nest which served them for years before, with a little dressing, will serve again; the difficulty of nestling lies only upon the young ones who have no nest. And not only the materials are wanting, but also the place in which to fix it. Every part of a tree will not do for this purpose, as some branches may not be sufficiently forked; others may not be sufficiently strong; and others may be too much exposed to the rockings of the wind.

The male and female upon this occasion are, for some days, seen examining all the trees of the grove very attentively; and when they have fixed upon a branch, fit for that purpose, they continue to sit upon and observe it very sedulously for two or three days longer.

The place being determined, they begin to gather the materials; such as sticks and fibrous roots, which they regularly dispose in the most substantial manner. But here a new and unexpected obstacle arises: it often happens that the young couple have made choice of a place too near the mansion of an older pair, who do not choose to be incommoded by neighbours. A quarrel, therefore, instantly ensues, in which the old ones are always victorious.

The young couple, thus expelled, are obliged again to go through the fatigues of examining and choosing; and having taken care to keep their due distance, the nest begins again. But they grow weary of bringing materials from distant places; and perceive that sticks may be provided nearer home. Away they go, therefore, to pilfer as fast as they can: and wherever they see a nest unguarded, they rob it of the choicest sticks of which it is composed. But these thefts never go unpunished. Eight or ten rooks come, and setting upon the new nest of the young couple at once, tear it in pieces in a moment.

At length, therefore, the young pair find the necessity of going more honestly to work. While one flies to fetch the materials, the other sits upon the tree to guard it: and thus in the space of three or four days, with a skirmish now and then between, the pair have fitted up a commodious nest, composed of sticks without, and fibrous roots and long grass within. From the instant the female begins to lay, all hostilities are at an end; not one of the whole grove, that a little before treated her so rudely, will now molest her; so that she brings forth her brood with patient tranquility. Such is the severity with which even native rooks are treated by each other, but if a foreign rook should attempt to make himself a denizen of their society: the whole grove would at once be up in arms against him, and expel him without mercy.

In all its habits the MAGPIE discovers a degree of instinct unusual to other birds. Its nest is not less remarkable for the manner in which it is composed, than for the place it is built in: either in the middle of some hawthorn bush, or on the top of some high tree.

It is always difficult of access; for the tree or bush pitched upon, usually grows in some thick hedge-row, fenced by brambles at the root. When the place is chosen, as inaccessible as possible to men, the next care is to fence the nest above from various enemies.

The kite, the crow, and the sparrow-hawk, are to be guarded against: as their nests have been sometimes plundered by the magpie, so it may be, they will take an opportunity to retaliate. To prevent this, the magpie's nest is built with surprising labour and ingenuity.

The body of the nest is composed of hawthorn branches; the thorns sticking outward, but well united together by their mutual in-

sertion. It is lined with fibrous roots, wool, and long grass, and nicely plaistered round with mud and clay. The body of the nest being thus made firm and commodious, the next work is to make the canopy which is to defend it above.

This is composed of the sharpest thorns, so woven together, as to deny all entrance except at the door, which is just large enough to permit egress and regress to the owners. In this fortress the male and female hatch and bring up their brood with security, sheltered from all attacks but those of the climbing school-boy, who often finds his torn and bloody hands too dear a price for the eggs or the young ones.

As the WOODPECKER is obliged to make holes in trees to procure food, so is it also to make cavities still larger to form its nest and to lay in. This is performed, as usual, with the bill. He chooses for this purpose trees that are decayed, or wood that is soft, like beech, elm, and poplar. In these, with very little trouble, it can make holes as exactly round as a mathematician could with compasses. One of these holes the bird generally chooses for its own use, to nestle, and bring up its young in: but as they are easily made, it is delicate in its choice, and often makes twenty before one gives entire satisfaction.

In our climate woodpeckers are contented with a wainscot habitation for their young; but in Guinea and Brazil, they take a very different method. A traveller who walks in the forests of these countries, among the first strange objects, is struck with the multitude of bird's nests hanging at the extremity of almost every branch. Many other kinds of birds build in this manner, but the chief of them are of the woodpecker kind.

In cultivated countries a great part of the caution of the feathered tribe is to hide their nests from the invasion of man. But in the depths of those remote and solitary forests, the little bird having nothing to apprehend from man, is careless how much the nest is exposed to general notice: satisfied if it be out of the reach of those rapacious creatures that live by robbery and surprise. If the monkey or the snake can be guarded against, the bird has no other enemies to fear; for this purpose, its nest is built upon the depending points of the most outward branches of a tall tree. On one of those immense trees, is seen the most various assemblage of creatures that can be imagined. The top is inhabited by monkeys of some particular tribe, that drive off all others: lower down twine about the trunk numbers of snakes, waiting till some unwary animal comes within their reach; and at the edges of the tree hang these artificial nests, inhabited by birds of the most delightful plumage.

The nests are usually formed in this manner: when the time of incubation approaches, they fly beautifully about, in quest of a kind

of moss, called by the English, old man's beard. It is a fibrous substance, not unlike hair, which bears being moulded into any form. This the little woodpecker first glues by some viscous substance, to the extreme branch of a tree; then building downward, a nest is formed, that descends like a pouch, from the point of the branch: the hole to enter at, is on the side; and all the interior parts are lined with the finer parts of the same substance which compose the whole.

Such is the general contrivance of these hanging nests; made by some other birds, with still superior art. A little bird in the Philippine islands, makes its nest in such a manner, that there is no opening but from the bottom. At the bottom the bird enters, and goes up through a funnel, like a chimney, till it comes to the real door of the nest, which lies on one side.

Some birds glue their nests to the leaf of the banana tree, which makes two sides of their little habitation; while the other two are artificially composed by their own industry. But these and all of the kind, are built with the same precautions, to guard their young against the depredations of monkeys and serpents. The nest hangs there, before the spoilers, a tempting object, which they can only gaze upon, while the bird goes in and out without danger and molestation.

The BIRD OF PARADISE appears to be as large as a pigeon, though in reality not much greater than a thrush. The tail is about six inches long, the wings are large, compared with the bird's other dimensions. The head, the throat, and the neck, are of a pale gold colour. The base of the bill is surrounded by black feathers, as also the side of the head and throat, as soft as velvet, and changeable like those on the neck of a mallard. The hinder part of the head is of a shining green, mixed with gold. The body and wings are chiefly covered with brown, purple and gold feathers. The uppermost part of the tail-feathers are of a pale yellow, and those under them white and longer than the former; for which reason the hinder part of the tail appears to be all white. But what chiefly excites curiosity, are, two long, naked feathers, which spring from the upper part of the rump above the tail, and are usually about three feet long. These are bearded only at the beginning and the end, the whole shaft, for above two feet nine inches, being of a deep black, the feathered extremity of a changeable colour.

This bird is a native of the Molucca Islands. There in the delightful and spicy woods, do these beautiful creatures fly in large flocks; so that the groves which produce the richest spices, produce the finest birds also. They are called by some, the SWALLOWS OF TERNATE, from their rapid flight, and from their being continually upon the wing, in pursuit of insects, their usual prey.

The American MOCK-BIRD, does not vie with the feathered inhabitants of that country in the beauty of his plumage. It is a plain bird, about the size of a thrush, of a white and gray colour, and a reddish bill. It is possessed not only of its own natural notes, which are musical and solemn, but can assume the tone of every other animal in the wood, from the wolf to the raven. It seems even to sport itself in leading them astray. It will at one time allure the lesser birds with the call of their males, and terrify them when they come near, with the screams of the eagle. There is no bird in the forest, but it can mimic; and there is none that it has not at times deceived by its call. But it is surest to please, when it is most itself.

At those times it frequents the houses of the American planters: and sitting all night on the chimney-top, pours forth the sweetest and the most various notes of any bird whatever.

The CRANE, is above three feet from the tip of the beak to the tail, and four feet from the head to the toe. It is a tall, slender bird, with a long neck and long legs. The top of the head is covered with black bristles, and the back of it is bald and red, which sufficiently distinguishes this bird from the stork, to which it is very nearly allied in size and figure.

Cranes were formerly known in this island, and held in great estimation for the delicacy of their flesh: there was even a penalty upon such as destroyed their eggs; but at present, they never go so far out of their way.

Cultivation and populousness go hand in hand; and though our fields may offer them a greater plenty, yet they find the venture greater than the enjoyment; and we are better off by their absence than their company.

The crane spends the autumn in Europe; then flies off to some more southern climate; returns to Europe in spring; crosses up to the north in summer; visits those lakes that are never dry; and then comes down to Italy in autumn.

In these journies it is amazing to conceive the height to which they ascend. Their note is the loudest of all birds; and is often heard in the clouds, when the bird itself is entirely unseen. But though unseen themselves, they have the distinct vision of every object below. They govern and direct their flight by their cries; and exhort each other to proceed or descend, when a fit opportunity offers.

Their loud clangorous sound is, when near, almost deafening: however, it is particularly serviceable to the animal itself, either during its migrations or stay: by it the flock is encouraged in their journies; and if while they are feeding, which is performed in profound silence, they are invaded on any side, the bird that first perceives it sounds the alarm, and all are speedily upon the wing.

The STORK also is a bird of passage, and goes away toward winter to the southern countries. It has a very long beak, and long, red legs. It feeds on serpents, frogs and insects. As it seeks for these in watery places, nature has provided it with long legs. And as it flies to the nest with its prey, its bill is strong and jagged, to hold fast what it has taken. She likewise digs with her bill into the earth for snakes or adders, which she carries to her young. Most of her feathers are white. She lays but four eggs, and sits for thirty days.

But what renders this bird more remarkable is, its steady love to its parents. It never forsakes them when they are old, but tenderly feeds and defends them, as long as they live.

The following adventure of a tame stork some years ago in the university of Tubingen, seems to shew a degree of understanding, which one would scarce expect in the brute creation. This bird lived quietly in the court-yard, till count Victor Gravenitz, then a student there, shot at a stork's nest, adjacent to the college, and probably wounded the stork then in it. This happened in autumn, when foreign storks usually leave Germany. The next spring a stork was observed on the roof of the college, which after a time came down to the upper gallery ; the next day something lower, and at last, by degrees quite into the court. The tame stork went to meet him with a soft cheerful note, when the other fell upon him with the utmost fury. The spectators drove him away ; but he came again the next day, and during the whole summer, there were continual skirmishes between them. The spring following, instead of one stork, came four, and attacked him all at once. A surprising event followed. All the turkies, ducks and geese, that were brought up in the court ran together, and formed a kind of rampart round him, against so unequal a combat. This secured him for the present. But in the beginning of the third spring, about twenty storks suddenly alighted into the court, and before the poor stork's life-guards could form themselves, or the people come to his assistance, they left him dead on the spot ; which none could impute to any thing but the shot fired by count Victor at the strange stork's nest.

The PELICAN somewhat resembles a swan. The body is as large, the neck nearly as long, the legs are short, and the feet are black, broad and webbed in the same manner. It is also of a whitish colour, only the tips of some of his feathers are black. It is much in the waters. It has a most horrid voice, like that of a man grievously lamenting.

Its beak is above a foot in length, and the point is very sharp. The upper part is formed as in other birds ; but the lower is unlike every thing in nature. It is made of two long flat ribs, with a tough membrane connected to one and the other. This reaches also to the

throat, and is very broad and loose, so that it can contain a vast quantity of provision.

Its eyes are very small; there is a sadness in its countenance; and its whole air is melancholy. They are torpid and inactive to the last degree, so that nothing can exceed their indolence, but their gluttony; it is only from hunger that they labour; otherwise they would continue in a fixed repose. When they have raised themselves thirty or forty feet above the sea, they turn their head with one eye downwards, and continue to fly in that posture. As soon as they perceive a fish near the surface, they dart upon it with the swiftnes of an arrow, seize it with unerring certainty, and store it up in their pouch. They then rise again, and continue hovering and fishing, with their head on one side as before.

This work they continue till their bag is full, and then fly to land to devour and digest it. This they are not long performing; for towards night they have another hungry call; and they again reluctantly go to labour. At night fishing is over, and they retire a little way from the shore; and though with the webbed feet and clumsy figure of a goose, they will be contented to perch no were but upon trees among the light and airy tenants of the forest. There they repose for the night; and often spend great part of the day, sitting in dismal solemnity, as it were half asleep. Their attitude is, with their head resting upon their great bag, and that resting upon their breast. There they remain without motion till the calls of hunger break their repose.

The same indolence attends them, even in preparing for incubation, and defending their young. The female makes no preparation for her nest, nor seems to choose any place to lay in; but drops her eggs on the bare ground to the number of five or six; and there continues to hatch them. Without any desire of defending her eggs or her young, she tamely sits, and suffers them to be taken from under her. Now and then she just ventures to peck or to cry out when a person offers to beat her off. She feeds her young with fish macerated in her bag: and when they cry, flies off for a new supply.

They are but disagreeable and useless domestics; their gluttony can scarcely be satisfied; their flesh smells very rancid, and tastes a thousand times worse than it smells. The native Americans kill vast numbers; not to eat, for they are not fit even for the banquet of a savage; but to convert their large bags into purses and tobacco-pouches. They bestow no small pains in dressing it with salt and ashes, rubbing it well with oil, and then forming it to their purpose. It thus becomes so soft and pliant, that the Spanish women sometimes adorn it with gold and embroidery to make work-bags of.

Yet with all the hebetude of this bird, it is not entirely incapable of instruction. The emperor Maximilian had a tame pelican which lived for above eighty years, and always attended his army on the march.

The ALBATROSS is one of the largest and most formidable birds of Africa and America. It is as large as a goose, of a brown colour, and is one of the most fierce of the aquatic tribe, not only living upon fish, but also such small water-fowl as it can take by surprise. It preys, as all the gull-kind do, upon the wing; and chiefly pursues the flying fish. These are every moment rising to escape from their pursuers of the deep, only to encounter equal dangers in the air. Just as they rise, the dolphin is seen to dart after them, but generally in vain. The gull has more success, and often takes them at their rise, while the albatross pursues the gull, so that the whole horizon presents but one living picture of rapacity and evasion.

But though this bird be one of the tyrants of the deep, there are some associations which even tyrants form, either by caprice, or necessity. The albatross has a peculiar affection for the PENGUIN. They choose the same places for breeding: some distant, uninhabited island, where the ground slants to the sea, as the penguin is not formed either for flying or climbing. In such places their nests are seen together, as if they stood in need of mutual assistance. Our men upon Falkland islands, were often amazed at the union preserved between those birds. In that bleak and desolate spot, where they no way dreaded the encroachments of men, they seemed to make their abode as comfortable as they expected it to be lasting. They built with an amazing degree of uniformity; their nests covering fields by thousands, and resembling a regular plantation. In the middle on high, the albatross raised its nest, built of heath, sticks, and long grass, about two feet above the surface; round this the penguins made their lower settlements, rather in holes in the ground, and most usually eight penguins to one albatross.

Nothing is a stronger proof that the presence of man, not only destroys the society of meaner animals, but their instincts also. These nests are now totally destroyed; the society is broke up, and the albatross and penguins have gone to breed upon more desert shores, in greater security.

The SWAN is as delicate in its appetite, as elegant in its form. Its chief food is corn, bread, herbs growing in the water and roots and seeds which are found near the margin. It prepares a nest in some retired part of the bank, and chiefly where there is an islet in the stream. This is composed of water-plants, long grass, and sticks; and the male and female assist in forming it with great assiduity. The swan lays seven or eight eggs, white, much larger than those of a goose. It

sits near two months before its young are excluded, which are ash-coloured for some months. It is dangerous to approach the old ones, when their little family is feeding round them. They soon take the alarm, and they sometimes give a blow with their pinion, that breaks a man's leg or arm.

It is not till they are a twelvemonth old, that the young swans change their colour with their plumage. All the stages of this bird's approach to maturity are slow; and mark its longevity. A goose has been known to live a hundred years, and the swan is supposed to live still longer.

The GOOSE, in its domestic state, exhibits a variety of colours. The wild goose always retains the same marks; the whole upper part is ash-coloured; the breast and belly are of a dirty white; the bill is narrow at the base, and at the tip it is black. These marks are seldom found in the tame; whose bill is entirely red, and whose legs are entirely brown. The wild goose is rather less than the tame; but both invariably retain a white ring round the tail, which shews that they are both descended from the same original.

The wild goose breeds in the northern parts of Europe; and in the beginning of winter, descends into more temperate regions. They are often seen flying at very great heights, in flocks from fifty to a hundred. Their cry is frequently heard when they are at an imperceptible distance above us; and this seems handed from one to the other, as among hounds in the pursuit.

Upon their coming to the ground by day, they range themselves in a line, and seem rather to descend for rest than refreshment. When they have sat in this manner for an hour or two, one of them, with a loud, long note, sounds a kind of charge, to which the rest attend, and pursue their journey with renewed alacrity.

The wild goose seldom lays above eight eggs; the tame goose often above twenty. The female hatches her eggs with great assiduity; while the gander visits her twice or thrice a day, and sometimes drives her off to take her place, where he sits with great state and composure.

But beyond that of all animals is his pride when the young are excluded: he seems then to consider himself as a champion; he pursues dogs and men that never attempt to molest him; and though the most harmless thing alive, is then the most petulant and provoking. When, in this manner, he has pursued the calf or the mastiff, to whose contempt alone he is indebted for safety, he returns to his female and her brood in triumph, clapping his wings, screaming, and shewing all the marks of conscious superiority.

The SOLUND-GOOSE, somewhat less than a land goose, is white: only the tips of its wings are black, and the top of the head yellow.

The bill is long, and so sharp pointed, that it pierces an inch deep into a board, when they stoop at fish, which are laid thereon. This is one way of catching them. When they sleep, they put their head under their wings: but one keeps watch. If that be surprised by the fowler, which frequently happens, all the rest are easily caught by the neck one after another. But if the sentinel cries and gives them warning, the whole flock escapes. When they fish for herrings, which come in shoals they fly nearly sixty yards high, and stoop perpendicularly. But when they aim at a single fish, they descend aslant.

There is always one tribe among them which is barren; these keep together, and never mix with them that build and hatch. (Is it not probable, that these are the males, like the drones among the bees?) The solund-geese come to the western isles in Scotland in March, taking the advantage of a south west wind They send a few before them who make a tour round the isles, and then return to their company. In a few days after, the whole flock comes together, and stays till September. All this time they are daily making up their nests in the shelves of high rocks. They fish, hatch and make their nests by turns. In order to this they amass together, not only heaps of grass, but whatever else they find floating on the water. In a nest on St. Kilda, was found a soldier's red coat, and some Molucca beans in another.

They are thought the sharpest sighted of all sea-fowls. They have a large gorget, somewhat like a pelican, in which one of them will preserve five or six herrings entire, and carry them to her nest, where they empty them out, for food to their young. Nay, they have been observed to go a fishing, to some isles which are thirty leagues distant, and bring the fish in their gorget all that way.

In the isle of Rona, (one of the Scotch western isles) there are a couple of eagles, which the natives say, not only drive away their young as soon as they are able to fly; but keep possession of the island, not suffering any of their kind to live there but themselves.

That which in Iceland they call the DOWN-BIRD, is very remarkable. It is a species of duck, but covered with fine, soft, downy feathers. The drake is full as large as a goose, but the duck considerably smaller. They abound all over Iceland, but particularly the western part, on account of the islands off the coast, where chiefly they build their nests. They build them with the down they pull from their breast. They lay four green eggs, as large as a goose. The inhabitants then take away both the eggs and the nest. The ducks go to work again, pull more down from their breasts, and lay four eggs more, which are again taken away by the inhabitants. This does not however discourage the duck. She builds a third nest, and

lays four more eggs: but the drake is now obliged to supply the down, the duck having none left. They now let her hatch her young: for if they disturb her a third time, she builds no more that year, nor ever returns to the same place. When the young have left the nest, they take it a third time, and so have two sets of eggs, and three parcels of down from the same nest.

The BAT seems a medium between bird and beast. But it comes nearer to the latter. They lay themselves up and sleep for the winter months, in the driest parts of caves. There, fixing their talons in the roof, they cover their bodies with their wings, and hang perpendicularly, in great numbers, but so as not to touch each other.

Who can account for another matter of fact which is particularly observed on the western islands? The western ocean throws up on their shores, great quantities of weather-beaten timber, on which hangs multitudes of little shells, fastened to one another, much as muscle-shells are. In every one of these shells is a perfect fowl: the little bill is like that of a goose; the eye marked; the head, neck, breast, wings, tail and feet formed. The feathers are perfectly shaped, and of a blackish colour, and the feet like those of other water-fowl: but we cannot hear of any person that ever saw any of them alive.

Now as bats are a kind of medium between beasts and birds, are not barnacles a kind of medium between birds and fishes:

I will conclude this account of birds, with one that seems to unite in itself somewhat of every class preceding. It is at once possessed of appetites for prey like the rapacious kinds, and an attachment to water like the birds of that element. It exhibits in its form the beautiful plumage of the peacock, the shadings of the humming-bird, the bill of the crane, and the short legs of the swallow. The bird I mean, is the KING-FISHER. It is not much larger than a swallow; its shape is clumsy; the legs very small, and the bill very long; it is two inches from the base to the tip; but the colours of this bird atone for its inelegant form. The crown of the head and the edges of the wings are of a deep blackish green, spotted with bright azure; the back and tail are of the most resplendent azure; the whole under side of the body is orange-coloured: a broad mark of the same passes from the bill beyond the eyes; beyond that is a large, white spot; the tail is short, and consists of twelve feathers of a rich, deep blue; the feet are of a reddish yellow.

From the diminutive size, and the beautiful colours of this bird, no person would be led to suppose it so rapacious an animal. It is ever on the wing, and feeds on fish, which it takes in surprising quantities, balancing itself at a certain distance above the water for a consider-

able space, then darting down and seizing the fish with inevitable certainty.

The king-fisher, with which we are acquainted, has none of those supposed powers of allaying the storm, or building upon the waves. It is contented to make its nests on the banks of rivers, in such situations as not to be affected by the rising of the stream. When it has found a place for its purpose, it hollows out with its bill a hole about a yard deep. Or if it finds the deserted hole of a rat, it takes quiet possession. This hole it enlarges at the bottom, and lining it with the down of the willow, lays its eggs there without any further preparation.

The female begins to lay early in the season, and excludes her first brood about the beginning of April. The male brings her large provisions of fish, while she is thus employed; and she, contrary to most other birds, is found fat at the season of hatching.

9. I have now only to add a few reflections.

And, 1. That birds should all lay eggs, and not bring forth live young, is a clear argument of Divine Providence, designing their preservation thereby. For if they had been viviparous, had they brought any number at a time, the burden of their womb must have been so great and heavy, that their wings would have failed, and they become an easy prey to their enemies. And had they borne but one at a time, they would have been bearing all the year.

2. Since it would have been many ways inconvenient to birds to to give suck; and yet inconvenient, if not destructive to the new-born chick, to pass suddenly from liquid to hard food, before the stomach was strengthened and able to digest it, and before the bird was accustomed to use its bill; and gather it up, which it does at first very slowly and imperfectly: therefore nature has provided in every egg a large yolk, which serves the chicken a considerable time instead of milk. Mean time it feeds by the mouth a little at a time, and that more and more, till the stomach is strengthened to digest it.

3. Birds that feed their young in the nest, though they bring but one morsel at a time, and have perhaps seven or eight, which all at once, with equal greediness, hold up their heads, and gape for it; yet never mistake, never omit one, but feed them all by turns.

4. Though birds cannot number, yet they are able to distinguish many from few. And when they have laid as many eggs as they can cover, they give over, and begin to sit. Yet they are not determined to such a number: they can go on and lay more at their pleasure. Hens, for instance, if you let their eggs alone, lay fourteen or fifteen, and give over. But if you withdraw their eggs daily, they will go on, to lay five times that number. This holds not only in domestic birds,

but also in the wild. A swallow, when her eggs were withdrawn daily, proceeded to lay nineteen.

5. It is remarkable, that birds, and such other oviparous creatures as are long-lived, have eggs enough conceived in them at first, to serve laying for many years, allowing such a proportion for every year, as will suffice for one or two incubations. Whereas insects, which are to breed but once, lay all their eggs at once, be they ever so many.

6. How exceeding speedy is the growth of birds that are fed by the old ones in the nest! Most of them come to near the full bigness, within the short term of a fortnight: an admirable provision, that they may not lie long in that helpless condition, exposed to the ravine of any vermin, and utterly unable to shift for themselves.

7. What amazing care do the parents take for the hatching and rearing of their young? First they seek out a secret and quiet place, where they may be undisturbed in their incubation. Then they make their nests, every one after his kind, that their eggs and young may be soft and warm: and those so elegant and artificial, as no art of man can imitate.

After they have laid their eggs, how diligently do they sit upon them, scarce giving themselves time to go off, to get them meat? When the young are hatched, how diligently do they brood over them lest the cold should hurt them? All the while labouring hard to get them food, and almost starving themselves lest they should want. Moreover, with what courage are they inspired, so as to venture their own lives in defence of them? The most timorous, as hens and geese, daring then even to fly in the face of a man. And all these pains are bestowed upon those that will render them no thanks for it! And they are bestowed just so long as is necessary. For when the young is able to shift for itself, the old retains no such affections for it, but will beat it indifferently with others.

8. It is another proof of a superintending Providence, that all animals are produced at the most convenient time of the year, just when there is food and entertainment ready for them. So lambs, kids, and many other living creatures, are brought into the world in the spring, when tender grass and nutritive plants are provided for their food. The like may be observed concerning silk-worms, whose eggs are hatched just when the leaves of the mulberry tree appear; the aliment being soft and tender, while the worms themselves are so, and growing more strong and substantial, as the insects increase in bulk and vigour.

9. A still farther proof hereof we have in the various instincts of animals, directed to ends which they know not, as, 1. All creatures know how to defend themselves, and offend their enemies. All know what their natural weapons are, and how to make use of them. A

boar knows the use of his tusks, a horse of his hoofs, a cock of his spurs, a bee of her sting. Yea a calf will make a push with his head, even before any horns appear. 2. Those creatures which have not strength to fight, are usually swift of foot or wing, and are naturally inclined to make use of that swiftness, and save themselves by flight. 3. Every creature knows and shuns its natural enemy, as a lamb does the wolf, and partridge or poultry, birds of prey. And they make use of a peculiar note, to warn their young of their approach, who thereupon immediately run to shelter. 4. As soon as ever it is brought forth, every animal knows its food. Such as are nourished with milk, immediately find their way to the paps, and suck: whereas those which are designed for other nourishment, never make any such attempt. 5. Birds that are fin-toed, or whole-footed, are naturally directed to go into the water. So ducklings, though hatched and led by a hen, if she brings them to the brink of a river or pond, presently leave her and go in, though they never saw any such thing before; and though the hen clucks and calls, and does all she can to keep them out. 6. Birds of the same kind make their nests of the same materials, laid in the same order, and exactly of the same figure, so that by the sight of the nest one may certainly know what bird it belongs to. And this, though living in distant countries, and though they never saw any nest made; that is, although they were taken out of the nest, and brought up by hand. Nor were any of the same kind ever known to make a different nest, either for matter or fashion: unless where the usual matter was not to be had: in that case, some birds use what they can get.

I would add a little farther improvement of some particulars mentioned before.

What master has taught birds, that they have any need of nests? Who has warned them, to prepare them in time, and not to suffer themselves to be prevented by necessity? Who hath shewn them how to build? What mathematician has given the figure of them? What architect has taught them to choose a firm place, and to build a solid foundation? What tender mother has advised them to cover the bottom with a soft and delicate substance, such as cotton or down, and when these fail, who has suggested to them that ingenious charity, to pluck off as many feathers from their own breast, as will prepare a soft cradle for their young?

Again. What wisdom has pointed out to each kind a peculiar manner of building? Who has commanded the swallow, to instance in one, to draw near to man, and make choice of his house for the building her nest, within his view, without fear of his knowing it, but seeming rather to invite him to a consideration of her labour? Nor does she build like other birds, with bits of sticks, and stubble, but

employs cement and mortar: and that in so firm a manner, that it requires some pains to demolish her work. And yet in all this, it has no other instrument to make use of but a little beak.

Yet again. Who has made the birds comprehend that they must hatch their eggs by sitting upon them? That this necessity is indispensable: that the father and mother could not leave them at the same time; and that if one went abroad to seek for food, the other must wait till it returns? Who has told them the precise number of days this painful diligence is to cost? Who has taught them to assist the young in coming out of the egg, by breaking the shell for them? Yea, and advertised them of the very moment, before which they never come!

Who has taught several of the birds that marvellous industry, of retaining food and water in their gullet, without swallowing either, and preserving them for their young, to whom this preparation serves instead of milk?

Is it for the birds, O Lord, who have no knowledge thereof, that thou hast joined together so many miracles! Is it for the men who give no attention to them? Is it for those who admire them, without thinking of Thee? Rather is it not thy design, by all these wonders, to call us to Thyself; to make us sensible of thy wisdom, and fill us with confidence in thy bounty, who watchest so carefully over those inconsiderable creatures, "two of which are sold for a farthing?"

But we pass from the industry of birds, to hearken for a moment to their music: the first song of thanksgiving which was offered on earth before man was formed. All their sounds are different, but all harmonious, and altogether compose a choir which we cannot imitate. One voice however more strong and melodious I distinguish above the rest. On inquiry I find it comes from a very small bird. This leads me to consider the rest of the singing birds. They likewise are all small: the great ones having a harsh and disagreeable voice. Such an amends is made to these weak, little creatures, for their defect of strength!

Some of these little birds are extremely beautiful, nor can any thing be more rich or variegated than their feathers. But it must be owned, that all ornament must give place to the finery of the PEACOCK; upon which God has plentifully bestowed all the riches which set off the rest, and lavished upon it with gold and azure, all the shades of every other colour. This bird seems sensible of its advantage, and looks as if it designed to display all its beauties to our eyes, when it stalks along, and expands that splendid circumference, which sets them all in open view.

But this pompous bird has of all others that are kept tame, the

most disagreeable cry, and is a proof, that there may be a shining outside, when there is little substance within.

In examining the feathers of the rest, I find one more circumstance very observable. That feathers of swans and other water fowl, are proof against the water. And accordingly they continue dry, though the creature swims or dives ever so long. And yet neither our eyes, nor all our art can discover, wherein they differ from others.

I know not how to conclude this chapter, without adding a few more reflections.

All the universe is replenished with life; and every part of it, with its proper animals. But would one expect to see them in the air! Nothing seems more natural to our eyes; but nothing is more astonishing to our reason. The fact is certain, and yet might seem to be altogether impossible. A bird in flight, is a mass raised aloft, in spite of the gravity of the air, and the tendency of all bodies to the earth. This mass is raised not by any foreign force, but by a movement suited to the purpose of the creature, and which sustained it in the air, for a considerable time, with a peaceful vigour.

Again. In the whole kingdom of birds, none have more than two wings, and yet they all fly in a different manner. Some launch away by repeated springs; others glide through the air with an even motion. These always skim over the earth; those soar up the clouds. Some know how to diversify their flight, by a straight, oblique, or circular motion: to suspend their bodies, and continue motionless in an element lighter than themselves: after this, to start into a horizontal motion, and then dart either to the right or left, wheel into a contrary tract, remount, and then precipitate themselves like a descending stone: in a word, they transport themselves, without opposition or hazard, wherever their necessities or pleasure call them.

The structure of their nests, the care with which they attend their eggs, the mechanism of the egg itself, and the birth and education of their young, are equally astonishing. See the perfect similitude that appears in all the nests of birds of the same species, the constant difference between the nests of one species and another! Together with the neatness and precaution which all of them observe.—One species builds its nest on the top of trees; another on the ground, under a canopy of grass: but always with a shelter, either of herbs, or a branch, or a double roof of leaves, down which the rain slides, without entering the opening, which lies concealed below. The outward part of the nest is made of solid materials, thorns, reeds, clay, or compact moss; the inner of softer materials, closely interwoven, so as to keep out both wind and insects. But each species has a peculiar taste. When the building is completed some hang the inside with a tapestry of feathers, or quilt it with wool or silk.

How admirably does this display the wisdom of Him who furnished man with reason, which extends to every thing around him, and inspired animals with an imitation of it, limited indeed to a few points, but admirable in that limitation! For who informed the bird, that she should lay eggs, and want a nest to lodge and nourish them with genial heat! That this heat would not be concentered round the eggs, if the nest were too large; and that were it smaller, it would not be capable of containing all the young. Who has taught her not to miscalculate the time, or lay her eggs before she had completed her nest?

The same wisdom will more fully appear, if we observe what the egg contains, with the manner how the young is there formed, and how it issues from its confinement.

The yolk lies in the heart of the egg, enclosed in the first membrane, which is surrounded by the second. Near the centre of the egg are the ligaments that sustain the yolk, which is contained in a peculiar membrane. A second membrane encloses the first white; a third and fourth encompass the whole. The shell is formed last of all, out of the salts evacuated from all the humours of the body, which the heat gradually fixes and consolidates, to serve a double purpose, first, that it may be excluded without crushing the contents; secondly, to defend their young, till it is thoroughly formed, and ready to forsake the egg.

Under the membrane which surrounds the yolk, is a white speck, which is the seed of the chick, in miniature. If the smallest portion of the vital spirit be infused into it from the male, by a process of which we have no idea, in the instant the chick receives life, and the whole substance is in motion. If it is not infused, the egg may indeed be laid, but it never comes to a living creature.

The pulsation of the heart bears some analogy to the pendulum of a clock, from whose vibrations the whole machine derives all its motions. The moment the heart begins to beat, the animal is alive, and receives by the umbilic duct, the nourishment which it transmits to the other vessels, whose branches distribute it to the whole body. All those little canals, which were flat before, are now swelled and enlarged. The whole substance imbibes a proper aliment, and the chick begins to grow.

In this situation of the speck, out of which it is formed, one circumstance is highly remarkable. This minute particle which is lodged on the film that includes the yolk is always near the centre of the egg, and toward the body of the dam, in order to be impregnated with a necessary warmth. But in how admirable a manner is this effected? The yolk is sustained by two ligaments, which fasten it on each side to the common membrane, that is glued to the shell. A line drawn from one ligament to the other, would not pass through the

middle of the yolk, but above the centre, and cut the yolk in two unequal parts, so that the smaller part which contains the seed, is of necessity raised towards the belly of the birds that sit: the other part as necessarily subsides, so that let the egg turn as it will, the young receives no hurt, but still enjoys a warmth that puts all about it in motion. So it feeds at ease, first on the white, which is more thin and delicate, and afterwards on the yolk, which affords more substantial nourishment. When his bill is hardened, and he grows uneasy at his confinement, he pecks and breaks the shell, and issues out fully replenished with the yolk, which nourishes him a little longer, till he is strong enough to raise himself upon his feet, and can march about to look for provisions.

CHAPTER III.

OF FISHES.

THE ocean is the great receptacle of fishes. It has been thought by some, that all fishes are naturally of the salt element, and that they have mounted up into fresh water, by some accidental migrations. A few still swim up rivers to deposit their spawn: but the great body of fishes, of which the size is enormous, and the shoals endless, keep to the sea, and would expire in fresh water. In that extensive and undiscovered abode, millions reside, whose manners are a secret to us, and whose very form is unknown. The curiosity of mankind, indeed, has drawn some from their depths, and his wants many more. With the figure of these at least he is acquainted: but for their pursuits, societies, antipathies, pleasures, times of gestation and manner of bringing forth, these all are hidden in the turbulent element that protects them.

1. The number of fish to which we have given names, and of the figure, at least, of which we know something, are above four hundred. Thus to appearance, the history of fish is tolerably copious; but when we come to examine, it will be found the greatest part of these we know very little of.

2. As most animals that live upon land have a covering to keep off the injuries of the weather, so all that live in the water, are covered with a slimy, glutinous matter, that like a sheath, defends their bodies from the surrounding fluid. This substance, secreted from the pores of the animal's body, serves not only to defend, but to assist the fish's easy progress through the water. Beneath this, in many kinds, is found a strong covering of scales, that, like a coat of mail, defends it

still more powerfully; and under that, before we come to the muscular parts of the body, an oily substance, which supplies the requisite warmth and vigour.

3. It is observable in all, that though their heads are much larger in proportion to their bodies, yet their brain is considerably less than that of other animals. It consists of only two small ventricles, placed in the forepart of the head.

4. Their organs of sense do not much differ from those of other animals. But in their eyes this is peculiar, that they are quite spherical, and that the optic nerves, in coming from the brain, cross each other: whereas in other animals they incline a little to each other, but do not meet. A protuberant eye would have been inconvenient for fishes, by hindering their motion in so dense a medium. And their continually brushing through the water, would have been apt to wear their eyes. Therefore their cornea is flat. But to make amends for this, and for the refraction of water, different from that of air, the wise Creator has made their crystalline spherical, which in other animals is more flat. It was formerly believed they did not hear at all. But from later experiments there is reason to believe that several species of them do hear, though but in a low degree. Over the two holes in their head, which serve for smelling, a fine membrane is spread, by which means they can open and shut them at pleasure; a contrivance highly necessary for creatures that live in the water.

The sense of smelling, which in beasts is so exquisite, and among birds is not wholly unknown, seems given to fishes in a very moderate proportion. It is true, that all fishes have one or more nostrils, and even those that have not the holes perceptible without, yet have the proper formation of the bones for smelling within. But as air is the only medium we know, for the distribution of odours, it cannot be supposed that these animals, residing in water, can be possessed of any power of being affected by them. If they have any perception of smells, it must be in the same manner as we distinguish by our taste; and it is probable, the olfactory membrane in fishes, serves them instead of a distinguishing palate: by this they judge of substances, that first tincturing the water with their vapours, are thus sent to the nostrils of the fish, and no doubt produce some kind of sensation. This most probably must be the use of that organ in those animals; as otherwise there would be the instrument of a sense provided for them, without any power in them of enjoyment.

Hearing in fishes is found still more imperfect, if it be found at all. Certain it is, that anatomists have not been able to discover, except in the whale-kind, the smallest traces of an organ of hearing, either within or without the head. Indeed, of what advantage would this sense be to animals that are incapable of making themselves heard?

They have no voice to communicate with each other, and consequently have no need of an organ for hearing.

Seeing seems to be the sense which fishes are possessed of in the greatest degree. And yet even this is obscure, if we compare it to that of other animals. The eye, in almost all fish, is covered with the same transparent skin that covers the rest of the head; and which probably serves to defend it from the water, as they are without eyelids. The globe of the eye is depressed before, and is furnished behind with a muscle, which serves to lengthen or flatten it, according to the necessities of the animal. The crystalline humour, which in beasts is flat, and of the shape of a button mould, in fishes is as round as a pea; or sometimes oblong, like an egg.

From all this, it appears, that fishes are extremely near-sighted; and that, even in the water, they can see objects only at a very small distance.

Thus nature seems to have fitted these animals with appetites and powers of an inferior kind; and formed them for a sort of passive existence in the obscure and heavy element to which they are consigned: to preserve their own existence, and to continue it to their posterity, fill up the whole circle of their pursuits and enjoyments.

5. Some fishes have LUNGS. But in the greater part the place of them is supplied by GILLS. As we take in and throw out the air by our lungs, so they take in the air, mixt with the water, by their mouth and throw it out by their gills.

There is always much air enclosed in water. This the gills separate from it, and present to the blood, as it is presented in the lungs of other animals. Each gill contains a great number of bony laminæ, consisting of an infinity of bony fibres, that sustain the innumerable ramifications of the veins and arteries, which present the blood extremely subdivided, and as it were, each globule by itself to the water: between the laminæ, through the whole contexture of the gills, are an infinity of very narrow passages, which receive and divide the water taken in by the mouth, into minute particles. Then the air, its prison-doors being in some measure opened, escapes and joins the blood of all the little arteries.

The gills have an alternate motion of dilatation and compression. When they dilate, the water is taken in; when they contract, it is driven out. It seems, that in the instant of contraction, the air expressed from the water is forced into the blood-vessels. It is the same, as to our lungs. The air enters them at the time of inspiration, but is received into the blood at the time of expiration only.—So that the water which is taken in by the mouth of fishes, when stript of its air, is carried off by the gills. Mean time, the air which is thus gained is distributed, first to those fine ramifications of the

arteries, which are expanded upon the gill throughout, and then to the veins inosculated therewith. And fishes can no more live without a constant supply of this, than land animals can.

The gills in all fishes are eight, four on each side. The lower gill is always smaller than the rest. The other three on each side are gradually larger to the top one, which is always the largest. Each of these is formed of a bony substance, bent into the shape either of a semicircle or a bow. On the convex side of this, there is a sort of plumes or leaves, each of which consists of a double row of bony lamella, formed like so many sickles, and fixed to the convex side of the bow by means of the membrane wherewith it is covered.

These lamella have one part convex, and the other concave. The concave part of each lamella is applied to the convex part of the next opposite lamella. Every lamella is invested with a fine membrane, which receives the ramifications of the blood-vessels. Every gill has an artery, a vein, and a nerve. The gills receive the blood which is thrown from the heart into the aorta, and drive it to the utmost parts of the lamella, from whence it returns by veins which distribute it throughout the body.

6. In most fishes the HEART is like that in other animals. But in some it has only one ventricle; which necessarily occasions a difference in the manner wherein the blood circulates. In some also the blood is not red, but clear and transparent. In others, especially shell-fish, besides the arteries and veins, there are open tubes, which convey the water to the farthest part of them: probably that they may find no want of water, when they continue some time on shore.

7. The AIR-BLADDER is described as a bag filled with air, sometimes composed of one, sometimes of two, and sometimes of three divisions, situated towards the back of the fish, and opening into the maw or the gullet. It is commonly supposed, by its swelling at the will of the animal, to increase the surface of the fish's body, and so to enable it to rise to the top of the water, and keep there at pleasure. On the contrary, when the fish wants to descend, it is supposed to empty this bladder of its air, and so sink to the bottom.

But many fishes have an air bladder, that continually crawl at the bottom; such as the eel and the flounder: and many more are entirely without it, that swim in every depth; such as the anchovy and the fresh water gudgeon. Indeed, the number of fishes that want this organ, is alone a sufficient proof that it is not necessary for the purposes of swimming: and the ventral fins, which in all fishes lie flat upon the water, are fully sufficient to keep them at all depths.

8. The STOMACH is, in general, placed next the mouth, and though not sensibly hot, is endued with a surprising faculty of digestion. Its digestive powers seem in some measure to increase with the quantity

of food it is supplied with; a single pike having been known to devour a hundred roaches in three days. Its faculties also are as extraordinary, for it digests not only soft fish, but prawns, crabs and lobsters, shells and all. These the cod or the sturgeon will not only devour, but dissolve, though their shells are so much harder than the sides of the stomach which contains them. This amazing faculty in the cold stomach of fishes has justly excited the curiosity of philosophers; and has effectually overturned the system of those who suppose the heat of the stomach is alone a sufficient instrument for digestion. The truth seems to be, that there is a power of animal assimulation lodged in the stomach of all creatures, which we can neither describe nor define, converting the substances they swallow into a fluid, fitted for their own peculiar support. This is done neither by trituration, nor by warmth, nor by motion, nor by a dissolving fluid; but by some principle yet unknown, which acts in a different manner from all kinds of artificial maceration.

Yet though fish are thus hungry, and for ever prowling, no animals can suffer the want of food for so long a time. The gold and silver fish which we keep in vases, seem never to want any nourishment at all; whether it be that they feed on the water-insects, too minute for our observation, or that water alone is a sufficient supply. Even the pike, the most voracious of fishes, will live in a pond where there is none but himself, and what is more extraordinary, will be often found to thrive there.

Air however is so necessary to all fish, that they can live but a few minutes without it; yet nothing is more difficult to be accounted for, than the manner in which they obtain this necessary supply. Those who have seen a fish in the water, must remember the motion of its lips and its gills, or at least of the bones on each side that cover them. This motion in the animal is, without doubt, analogous to our breathing, but it is not air, but water, that the fish actually takes in and throws out through the gills at every motion.

The manner of its breathing seems to be this. The fish first takes a quantity of water by the mouth, which is driven to the gills, these close and keep the water so swallowed from returning by the mouth, while the bony covering of the gills prevents it from going through them, until the animal has drawn the proper quantity of air from the body of water thus imprisoned: then the bony covers open and give it a free passage; by which means also the gills again are opened, and admit a fresh quantity of water. Should the fish be prevented from the free play of its gills, or should the bony covers be kept from moving, by a string tied round them, the animal would soon fall into convulsions, and die in a few minutes.

9. The chief instruments in a fish's motion are the FINS, which in

some are much more numerous than in others. A fish completely fitted for sailing is furnished with two pair; also three single fins, two above and one below. Thus equipped, it migrates with the utmost rapidity, and takes voyages of a thousand leagues in a season. But such fish as have the greatest number of fins have not always the swiftest motion. The shark is one of the swiftest swimmers, yet it wants the ventral fins; the haddock does not move so swift, though it has them.

The fins not only assist the animal in progression, but in rising and sinking, in turning, or even leaping out of the water. To answer these purposes, the pectoral fins serve like oars, to push the animal forward. They are placed behind the opening of the gills; they are generally large and strong, and answer the same purpose to the fish as wings do to a bird. Those also balance the fish's head, when it is too large for the body, and keep it from tumbling prone to the bottom, as is seen in large-headed fishes, when the pectoral fins are cut off. Next these are the ventral fins, placed under the belly. These are always seen to lie flat on the water, in whatever situation the fish may be; and they serve rather to raise or depress the fish, than to assist its progressive motion. The dorsal fin is situate along the ridge of the back; and serves to keep it in equilibrio. In many fishes this is wanting; but in all flat fishes it is very large, as the pectoral fins are proportionably small. Lastly, the tail, which in some fishes is flat and upright in others, seems to be the grand instrument of motion; the fins are all subservient to it, and give direction to its impetus, by which the fish darts forward with so much velocity. To explain all this, by experiment, a carp is taken, and put into a large vessel. The fish, in a state of repose, spreads all its fins, and seems to rest upon its pectoral and ventral fins, near the bottom: if the fish folds up either of its pectoral fins, it inclines to the same side; folding the right pectoral fin, the fish inclines to the right side; folding the left fin, it inclines to that side. When the fish desires to have a retrograde motion, striking with the pectoral fins, in a contrary direction, produces it. If the fish desires to turn, a blow from the tail, send it about; but if the tail strikes both ways, then the motion is progressive.

10. There is something extremely odd in the experiments of an ingenious man, on some of our common fishes.

"I put a bansticle," says he, "in a glass jar filled with water; at first it refused to eat any thing, which is common with all fishes; but afterward it grew so tame, as to take small worms out of my hand. Nay, it was so bold at last, that when its belly was full, it would set up its prickles, and with all its strength, make a stroke at my fingers, if I put them near it.

"This fish was so unsociable, that it would suffer no other fish to live in the jar with it, and so audacious as to attack whatever I put in, though ten times its own size. One day I put in a small ruff; the bansticle instantly assaulted it, and tore off part of its tail, and I am persuaded would have killed it, had I not separated them.

"The abilities they use to get from place to place, are likewise extraordinary. Though they are scarce two inches long, I have seen them leap out of the water a foot perpendicularly, and much farther obliquely, when they wanted to get over some obstacle in the way.

"Nature has furnished them with a kind of breast-plate, to be a defence against outward injury, and with prickles upon their sides and back, which they erect on the least appearance of danger.

"I have always observed among the fish I keep in jars, that such as I keep awhile together, contract so great an affection for each other, that if they are separated, they grow melancholy and sullen. About Christmas I put two ruffs into a jar, where they lived together till April. I then gave one of them to a friend, the other was so affected, that for three weeks it would eat nothing. Fearing it would pine to death, I sent it to its companion: being put to this, it ate immediately, and presently recovered its former briskness.

"In the beginning of September," says the same gentleman, "I procured a small dace, which I kept in a glass jar till the latter end of May following. All this while it ate nothing except the small animalcules, which happened to be in the water I gave it, once a day in winter, and twice or thrice in the spring, as the weather grew warmer. When the water was fresh, it came up to the top about once an hour, to blow out some small bubbles of air. Then putting its nose near the surface, it took in fresh, and retired to the bottom again. But as the water became less pure by its use, its returns to the surface were more frequent, and at last it would remain there continually, till I gave it a fresh quantity. I believe I might have kept it for years, but business one day prevented me from giving it clean water in due time, which put a period to the life of my little companion.

"At first it would not suffer me to come nigh the glass, without the utmost confusion and surprise; but at last it grew so tame, that if I came but in sight, it would be sure to be at the same side of the glass, and lie gazing at me, until I was weary of observing it. I often took the opportunity of looking at it by candle-light which it seemed to take great pleasure in.

"In the above-mentioned month, I put into another glass, a ruff about three inches long. At first he too appeared mighty reserved, and would not eat, nor suffer me to come nigh him: but in a short time all-powerful hunger tamed him: for he could not, like the dace,

live on the small inhabitants of the water, and so was quickly forced to take whatever I provided for him. In a while it grew so tame, that it would not only eat small worms, which I threw into the glass, but would take them out of my hands. Nay, it would even rise out above the water for them; which is contrary to the way wherein this kind of fish uses to take its food. At last it would come to my hand, whenever I put it into the glass, and suffer me to handle it. When I had made all the observations I thought proper, after eight months I gave him his liberty."

11. It has long been supposed that all shells, as well as the animals in them, arose wholly from the egg. But it is now found by various experiments, that the shells of snails, and probably of all other animals, are formed of a matter which perspires from their bodies, and then condenses round them.

It is certain all animals perspire and are encompassed with an atmosphere which exhales from them. Snails have nothing peculiar in this respect, unless that their atmosphere condenses and hardens about them, and forms a visible cover for the body, while that of other animals evaporates. This difference may arise from the different substances perspired; that from snails being viscous and stony. This is no supposition, but a matter of fact, proved by numerous experiments.

But the reproduction of the shells of some fish, yea, and of the parts contained therein, is far more strange and unaccountable, than their first production. This is particularly observed in crabs and lobsters. Lobsters cast their shell yearly, some time after midsummer. In the room of the old, a new, thin shell is immediately prepared by nature, which in less than eight days, acquires almost the same degree of hardness as the other.

The legs of a lobster consist of five articulations. When any of these legs break, which frequently happens, the fracture is always near the fourth joint, and what they lose is precisely reproduced in some time after: four joints shooting out, the first whereof has two claws, as before.

If a leg be broken off purposely at the fourth or fifth joint, it is constantly reproduced: but very rarely, if at the first, second, or third joint. What is still more surprising is, that upon visiting the lobster, which is maimed in these barren articulations, at the end of two or three days, all the other joints are found broken off at the fourth, which he has undoubtedly done himself.

The part reproduced is perfectly like that broke off, and in a certain time grows equal to it. Hence it is, that lobsters have often their two big legs unequal. This shews the smaller leg to be a new one. If a part thus reproduced is broken off, there is a second reproduc-

tion. The summer, which is the only time when lobsters eat, is the most favourable time for this. It is then performed in four or five days; otherwise it takes up eight or nine months.

The common crab-fish has its abode in from twenty to forty fathom water. They herd together in distinct tribes, and have their separate haunts for feeding and breeding, and will not associate with their neighbours. This has been tried, by marking a crab, carrying it two or three miles, and leaving it among other crabs. This crab has afterward found its way home, and been caught in its old abode.

This creature too can break off its own limbs. If when it is laid on its back, one of the outer joints of a small leg be bruised, he shews uneasiness by moving it about. Afterward he holds it quite still, in a direct and natural position, without touching any part of the body, or of the other legs with it. Then on a sudden with a gentle crack, the wounded part of the leg drops off. If a hole be pierced in the great leg, the effect will be the same: and the large limb is thrown off in the same manner, only with greater violence. A mucus then overspreads the wound, which presently stops bleeding; and a small leg is by degrees produced, which gradually attains the size of the former. Nature has given this singular power to these creatures, for the preservation of their lives in their frequent quarrels. In these, one crab lays hold of the claw of another, and crushes it in such a manner, that it would bleed to death, had it not the power of giving up the limb, and healing the wound.

However different in figure the lobster and the crab may seem, their manners are nearly the same. Though without any warmth in their bodies, or even red blood, they are wonderfully voracious. Whatever they seize upon that has life, is sure to perish, though never so well defended: they even devour each other: and, to increase our surprise, they may, in some measure, be said to eat themselves, as they change their shell and their stomach every year, and their old stomach is generally the first morsel that serves to glut the new.

What this animal differs in from all others, is, that the spinal marrow is in the breast bone. It is furnished with two long feelers or horns, that issue on each side of the head, to correct the dimness of its sight, and apprize the animal of its danger or of its prey. The tail is the grand instrument of motion; and with this it can raise itself in the water.

When the young lobsters leave the parent, they seek for refuge in the smallest clefts of rocks, and in crevices at the bottom of the sea. There they grow larger in a few weeks, from the accidental substances which the water washes to their retreats. By this time also they acquire a hard firm shell, which furnishes them with both offensive

and defensive armour. They then issue from their fortresses, and creep along the bottom, in hopes of meeting with plunder. The spawn of fish, the smaller animals of their own kind, and chiefly the worms that keep at the bottom of the sea, supply them with plenty. They keep in this manner close among the rocks, busily employed in scratching up the sand with their claws for worms, or surprising such heedless animals as fall within their grasp: thus they have little to apprehend, except from each other, for in them, as among fishes, the large are the most formidable of all enemies to the small.

But the body of the lobster still continuing to increase, the animal soon becomes too large for its habitation. In general, all animals change their shell once a year; and this is a most painful operation. Their moulting season is generally about the beginning of summer: at which time their food is in plenty, and their strength and vigour in the highest perfection. But soon all their activity ceases: they seek some retired situation among the rocks, where they remain in safety from the attacks of their various enemies. For some days before their change, the animal discontinues its usual voraciousness; it is no longer seen harrowing up the sand at the bottom, or fighting with others of its kind, or hunting its prey: it lies torpid and motionless. Just before casting its shell, it throws itself upon its back, strikes its claws against each other, and every limb seems to tremble; its feelers are agitated, and the whole body is in violent motion. It then swells itself in an unusual manner, and at last the shell begins to divide at its junctures; particularly at the junctures of the belly, where like a pair of jumps, it was before but seemingly united. It also seems turned inside out; and its stomach comes away with its shell. After this it disengages itself of the claws, which burst at the joints; the animal, with a tremulous motion, casting them off, as a man would kick off a boot that was too big for him.

Thus this wonderful creature is at liberty; but so weak that it continues for several hours motionless. Indeed, so violent and painful is the operation, that many of them die under it; and those which survive, for some time, neither take food, nor venture from their retreats. Immediately after this change, they have not only the softness, but the timidity of a worm. Every animal of the deep is then a powerful enemy, which they can neither escape, nor oppose; and this is the time when the dog-fish, the cod, and the ray devour them by hundreds. But this state continues for a very short time: in less than two days, the skin that covered its body is grown almost as hard as before.

When the lobster is completely equipped in its new shell, it appears how much it has grown in the space of a very few days. The old shell being compared with those of the new, it is increased above

a third in its size; and, like a boy that has outgrown his clothes, it seems wonderful how the deserted shell was able to contain so great an animal as entirely fills up the new.

It may be worth observing, that lobsters use their tails as fins, wherewith they commonly swim backward, by jerks or springs, reaching sometimes ten yards at a spring. For this purpose, as the gill-fins of other fishes, which are their oars, are a little concave backward, these have the plates of their tails, when they bend them down as they use to do, a little concave forward.

Different from all these are the land crabs of the Caribbee islands; which live in a kind of orderly society, within their retreats in the mountains: and regularly once a year march down to the sea side in a body of some millions. They choose the months of April and May to begin their expedition: and then sally out from the stumps of hollow trees, from the clefts of rocks, and from the holes which they dig for themselves under the surface of the earth. At that time the whole ground is covered with this band of adventurers. The sea is their place of destination, and to that they direct their march. No geometrician could send them to their destined station, by a shorter course. They never turn to the right or left, whatever obstacles intervene. And even if they meet with a house they will attempt to scale the walls, to keep the unbroken tenor of their way. But upon some occasions they are compelled to conform to the face of the country; and if it be intersected by rivers, they wind along the course of the stream. They are commonly divided into three battalions; of which, the first consists of the strongest and boldest males, that like pioneers, march forward to clear the route, and face the greatest dangers. These are often obliged to halt for want of rain, and wait till the weather changes. The main body of the army is composed of females, which never leave the mountains till the rain is set in, and then descend in regular battalia, in columns of fifty paces broad, and three miles deep, and so close, that they almost cover the ground. Three or four days after this, the rear-guard follows: a straggling undisciplined tribe, consisting of males and females, but neither so robust, nor so numerous as the former. The night is their chief time of proceeding; but if it rains by day, they do not fail to profit by the occasion; and they continue to move forward in their slow, uniform manner. When the sun shines hot, they make an universal halt, and wait till the cool of the evening. When they are terrified they march back in a disorderly manner, holding up their nippers with which they sometimes tear off a piece of the flesh of an assailant, and leave the weapon where they inflicted the wound. They often clatter their nippers together, as if it were to threaten those that come to disturb them. But though they thus strive to be

formidable to man, they are much more so to each other; for if any of them by accident is maimed in such a manner as to be incapable of proceeding, the rest fall upon and devour it on the spot, and then pursue the journey.

When after a fatiguing march, perhaps of three months, they arrive at their destined port, they prepare to cast their spawn. The peas are as yet within the bodies, and not, as is usual in animals of this kind, under the tail. And the creature waits for the benefit of the sea-water, to help the delivery. For this purpose, the crab has no sooner reached the shore, than it eagerly goes to the edge of the water, and lets the wave wash over its body, two or three times. Then they withdraw to seek a lodging upon land: in the mean time, the spawn grows larger, is excluded out of the body, and sticks to the barbs under the tail In this state of pregnancy, they once more seek the shore, and shaking off their spawn into the water, leave it there. At this time whole shoals of hungry fish are in expectation of this annual supply. The sea, to a great distance, is black with them; and about two-thirds of the crab's eggs are immediately devoured. The eggs that escape are hatched under the sand; and soon after, millions at a time of these little crabs are seen quitting the shore, and slowly travelling up to the mountains.*

The old ones, however, are not so active to return: they are become so feeble, that they can hardly creep along. Most of them, therefore, are obliged to continue in the flat parts of the country till they recover, making holes in the earth, which they cover at the mouth with leaves and dirt. There they throw off their old shells. At that time they are quite naked, and almost without motion for six days. They have then under their stomachs four large white stones, which gradually decrease in proportion as the shell hardens, and when they come to perfection, are not to be found. It is at that time the animal is seen slowly making its way back, and all this is commonly performed in six weeks.

There is likewise an animal of the lobster-kind, that annually descends from its mountains, not only to produce an offspring, but to provide itself a covering: not only to secure a family, but to furnish a

* The instinct of this creature is truly admirable. As soon as the young ones find themselves in a situation fit to commence their journey, they all repair to the general rendezvous, and forming themselves in regular divisions, and battalions, commence their march by millions, the order of which is not to be broken by any intervening obstacles. At this time the natives assemble and destroy them by thousands. It should be observed that they generally march in three columns, and between the advance and the rear, may be found many stragglers: but what is truly surprising, when the rear has passed, not a single straggler is to be found: for if they overtake any that are decrepid, and cannot continue their march, they fall upon them and devour them.

house. I mean the SOLDIER-CRAB. It is about four inches long, has no shell behind, but is covered down to the tail with a rough skin, terminating in a point. But what nature has denied this animal, it takes care to supply by art; and taking possession of the deserted shell of some other animal, it resides in it, till, by growing too large for its habitation, it is under the necessity of a change. It is a native of the West-India islands, and every year descends from the mountains to the sea-shore, to deposit its spawn, and to provide itself with a new shell. Its first care is to provide for its offspring, and it is thought, from the number of little shells which it is seen examining, that it deposites its spawn in them, which thus is placed in perfect security all the time of exclusion.

It is thus mindful of itself. It is still seen in its old shell, which it has considerably outgrown: a part of the naked body is seen at the mouth of it, which the habitation is too small to hide. A shell, therefore, is to be found large enough to cover the whole body; and yet not so large as to be unmanageable. To answer both these ends is no easy matter, nor the attainment of a slight inquiry. The little soldier is seen busily parading the shore, along that line of pebbles and shells that is formed by the waves; still, however, dragging its old habitation at his tail; unwilling to part with one shell, till it can find another more convenient. It is seen stopping at one shell, turning it and passing it by, going on to another, contemplating that for a while, and then slipping its tail from its old habitation, to try on the new. This also is found to be inconvenient, and it quickly returns to its old shell again. In this manner it frequently changes, till at last it finds one, light, roomy, and commodious. To this it adheres, though the shell be sometimes so large as to hide the body of the animal, claws and all.

Yet it is not till after many trials, and many combats also, that the soldier is thus completely equipped. For there is often a contest between two of them, for some well-looking shell. They both endeavour to take possession: they strike with their claws: they bite each other, till the weakest is obliged to yield. It is then that the victor takes possession, and parades in his new conquest three or four times backward and forward upon the strand, before his envious antagonist.*

Crabs'-eyes, so called, are found in the bodies of CRAY-FISH. Each fish produces two yearly, one on each side of the stomach, between

* The meat of this crab, when properly cooked is considered a great delicacy, and very nourishing. The natives where it abounds, ascribe to it high specific virtues. It is said that the meat of this crab will dissolve into a kind of oil, if hung in the open air, and that it is a certain and speedy cure for the rheumatism, if rubbed well on the parts affected.

the coats of it. Here it grows, coat upon coat, and is supplied with petrifying juices, by vessels opening on the inner surface of the outward coat. The first scale, whereon all the others are formed, may be perceived in the centre; the brims or circumferences of many of the rest being likewise apparent. It is believed, that they cast these stones with their shells yearly; but this is not the case. For about the time of casting their shell, the stones break through the internal coat of the stomach, and being ground by the three serrated teeth therein, become dissolved in the space of a few days which makes it difficult to find them just at this time.

They eat their old shells immediately after shedding them. Perhaps these stones may be designed to furnish new petrescent juices to its fluids, for the reproduction of their annual dress.

As to turbinated shell-fish, of the SNAIL-KIND, we may first observe the SNAIL itself. This is surprisingly fitted for the life it is to lead. It has the organs of life in a manner almost as complete as the largest animal; a tongue, brain, salival ducts, glands, nerves, stomach, and intestines; liver, heart, and blood-vessels; besides this, it has a purple bag that furnishes a red matter to different parts of the body, together with strong muscles, that hold it to the shell, and which are hardened like tendons at their insertion.

But these it possesses in common with other animals. We must now see what it has peculiar to itself. The first striking peculiarity is, it has got its eyes on the points of its largest horns. When the snail is in motion, four horns are seen distinctly; but the two longest deserves peculiar consideration, both on account of the various motions with which they are endued, and of their having eyes at the extreme ends of them. These appear like two blackish points. The animal can direct them to different objects at pleasure, by a regular motion out of the body; and sometimes it hides them by a very swift contraction into the belly. Under the small horns is the animal's mouth; and though it may appear too soft a substance to be furnished with teeth, yet it has no less than eight of them, with which it devours leaves, and other substances seemingly harder than itself.

It may seem whimsical to make a distinction between the animal perfections of turbinated and bivalved shell-fish, or to grant a degree of superiority to the SNAIL above the OYSTER. Yet this distinction apparently obtains in nature; and we shall find the bivalved tribe of animals in every respect inferior to the other. Inferior in all their sensations; inferior in all their motions; but particularly inferior in their system of animal generation. The snail tribe are hermaphrodite; but require the assistance of each other for fecundation; all the bivalve tribe are hermaphrodite in like manner, but they require no assistance from each other towards impregnation; and a single

muscle or oyster, if there were no other in the world, would quickly replenish the ocean.

The multitude of muscles is in some places very great; but from their defenceless state, the number of their destroyers are in equal proportion. The crab, the cray-fish, and many other animals, are seen to devour them: but the tochus is their most formidable enemy. When their shells are found deserted, if we then observe closely, it is most probable we shall find that the tochus has been at work in piercing them. There is scarce one of them without a hole in it; and this probably was the avenue by which the enemy entered to destroy the inhabitant.

But notwithstanding the number of this creature's animated enemies, it seems still more fearful of the agitations of the element in which it resides: for, if dashed against rocks, or thrown far on the beach, it is destroyed without a power of redress. In order to guard against these, which are to this animal the commonest and the most fatal accidents, although it has a power of slow motion, which I shall presently describe, yet it endeavours to become stationary, and to attach itself to any fixed object it happens to be near. For this purpose it is furnished with a very singular capacity of binding itself by a number of threads to whatever object it approaches: and these, Reaumur supposes, it spins artificially, as spiders their webs, which they fasten against a wall. Be this as it will, nothing is more certain than that the muscle is found attached by these threads to every fixed object; sometimes indeed, for want of such an object, these animals are found united to each other, and though thrown into a lake separately, they are taken out in bunches of many together.

To have some fixed resting place, where the muscle can continue, and take in its accidental food, seems the state that this animal chiefly desires. Its instrument of motion, by which it contrives to reach the object it wants to bind itself to, is that muscular substance resembling a tongue, which is found long in proportion to the size of the muscle. This the animal has a power of thrusting out of its shell: and with this it is capable of making a slit in the sand at the bottom. By means of this furrow it can erect itself upon the edge of its shell: and thus continuing to make the furrow, in proportion as it goes forward, it reaches out its tongue, that answers the purpose of an arm, and thus carries its shell edge-ways, as in a groove, until it reaches the point intended. Then, where it determines to take up its residence, it fixes the ends of its beard, which are glutinous, to the rock, or the object, whatever it be; and thus like a ship at anchor, braves all the agitations of the waters. Sometimes the animal is attached by a large number of threads; sometimes but by three or four, that seem scarce able to retain it. When the muscle is fixed in this man-

ner, it lives upon the little earthy particles that the water transports to its shells, and perhaps the flesh of the most diminutive animals. However, it does not fail to grow considerably; and some of this kind have been found a foot long. I have seen the beards of a foot and a half; and of this substance the natives of Palermo make gloves and stockings.

Oysters usually cast their spawn in May, which at first appear like drops of candle grease, and stick to any hard substance they fall upon. These are covered with a shell in two or three days, and in three years the animal is large enough to be brought to the market.

The SCALLOP is particularly remarkable for its method of moving forward upon land, or swimming upon the water. When it finds itself deserted by the tide, it moves towards the sea in a most singular manner. It first gapes with its shell as widely as it can, the edges being often an inch asunder: then it shuts them with a jerk, and by this the whole animal rises five or six inches from the ground. It thus tumbles any how forward, and renews the operation until it has attained its journey's end. When in the water it is capable of supporting itself on the surface; and there opening and shutting its shells, it tumbles over and over, and makes its way with some celerity.

The RAZOR-SHELL has a very different kind of motion. As the former moves laboriously forward, so the razor-shell has only a power of sinking downward. The shells of this animal resemble nothing so much at the haft of a razor; and by this form it is enabled to dive into the soft sand. All its motions are confined to sinking or rising a foot downwards or upwards in the sand, for it never leaves the spot where first it was planted. From time to time it raises about half way out of its hole: but if any way disturbed sinks perpendicularly down again. Just over the place where the razor buries itself, there is a small hole like a chimney, through which the animal breathes or imbibes the sea water. Upon the desertion of the tide, these holes are easily distinguished by the fishermen; and their method of enticing the razor up is by sprinkling a little sea-salt upon the hole.—This melting no sooner reaches the razor below, than it rises instantly, and shows above half its length above the surface. This appearance is instantaneous; and if the fisher does not seize the opportunity, the razor buries itself to its former depth. There it continues secure; no salt can allure it the second time; but it remains unmolested unless the fisher will be at the trouble of digging it out, sometimes two feet below the surface.

Multivalve SHELL-FISH may be considered as animals shut up in round boxes. To view their habitations externally, one would be little apt to consider them as the retreats of living creatures; and

still less, to suppose that some of them carry their boxes with a tolerable share of swiftness, so as to escape their pursuers. Of these there are principally two kinds; such as move, and such as are stationary: the first are usually known in our cabinets by the name of sea-eggs; the others are often admired for the cavities which they scoop out for their habitation in the hardest marble. The first are called, by naturalists, echini, or urchins: the latter are called pholades, or file-fish. Of both these are several sorts; but by describing these two, we shall have a competent idea of all the rest.

To a slight view, the sea-urchin may be compared to the husk of a chesnut; being like it, round, and with a number of bony prickles standing out on every side. If we could conceive a turnip stuck full of pins on every side, and running upon these pins with some degree of swiftness, we should have some idea of this extraordinary creature. The mouth is placed downwards; the vent is above; the shell is a hollow vase, resembling a scooped apple; and this filled with a soft muscular substance through which the intestines wind from the bottom to the top. The mouth, which is placed undermost, is large and red, furnished with fine sharp teeth, which are easily discerned. The jaws are strengthened by fine small bones, in the centre of which is a small fleshy tongue; and from this the intestines make a winding of five spires, round the internal sides of the shell, ending at the top, where the excrements are excluded. But what makes the most extraordinary part of this animal's conformation, are its horns, and its spines, that point from every part of the body, like the horns of a snail, and that serve at once as legs to move upon, as arms to feel with, and as instruments of capture and defence. Between their horns it has also spines that are not endued with such a share of motion. The spines and the horns issue from every part of the body, the spines being hard and prickly, the horns being softer, longer than the spines, and never seen except in the water. They are put forward and withdrawn like the horns of a snail, and are hid at the base of the spine, serving, as was said before, for procuring food and motion. All this aparatus, however, is only seen when the amimal is hunting his prey at the bottom of the water; for a few minutes after it is taken, all the horns are withdrawn into the body, and most of the spines drop off.

It is generally said of insects, that those which have the greatest number of legs, always move the slowest; but this animal seems to be an exception to the rule; for though furnished with two thousand spines, and twelve hundred horns, all serving for legs, and which from their number seem to impede each other's motion, yet it runs with some share of swiftness at the bottom, and it is sometimes no easy matter to overtake it.

Very different in motion, though not much different in shape from them, are the acorn shell-fish, the thumb-footed shell-fish, and the imaginary barnacle. These are fixed to one spot, and appear to vegetate from a stalk. Indeed, to an inattentive spectator, each actually seems to be a kind of fungus that grows in the deep, destitute of animal life, as well as motion. But the inquirer will soon change his opinion, when he comes to observe this mushroom-like figure more minutely. He will then see that the animal residing within the shell, has not only life, but some degree of voraciousness; that it has a cover, by which it opens and shuts its shell at pleasure: that it has twelve large crooked arms, furnished with hair, which it thrusts forth for its prey; and eight smaller, which are generally kept in the shell. They are seen adhering to every substance that is to be met with in the ocean; rocks, roots of trees, ships' bottoms, whales, lobsters, and even crabs; like bunches of grapes clung to each other. It is amusing enough to behold their operations. They for some time remain motionless within their shell; but when the sea is calm, they are seen opening the lid, and peeping about them. They then thrust out their long neck, look round them for some time, and then abruptly retreat back into their box, shut the lid, and lurk in darkness and security.

Among the shell-fish on the Waterford coast, is the MUREX, which gave the Tyrian purple. It is in great plenty there, and is by the English called a horse-winkle. The shell is about an inch long, and half an inch broad, and turns spirally like a snail's shell. Each fish has a peculiar reservoir, which contains a large drop of liquor; if this is pressed out on linen, the linen first appears of a dirty yellow, inclining to green; afterward it changes to a lemon colour, then to a deep green; then it turns to a deep blue, and at last to a charming purple.

The shells of the ancient purple-fish, are still common on the Tyrian shore. The fish itself is found in great abundance in the seas of the Spanish West indies, near Panama and Nicoya, exactly agreeing with Pliny's account of the ancient Murex. Cloth of Segovia, died with purple, is sold for twenty crowns an ell, and is very rarely worn by any, but the greatest noblemen in Spain. The Caribbee islands have also the same sort of fish, which we may likewise find nearer home, namely on the coasts of Somersetshire, as well as of South Wales.

The PEARL MUSCLES lie partly open: the inside of the shell is of a pearly colour. The pearl lies in the smaller end of it, at the extremity of the gut, and out of the body of the fish, between the two films that line the shell. This answers to the stone in the other animals, increasing by crusts growing over one another. Accordingly if

a pearl be pinched in a vice, the upper coat will crack and leap away. And as it is now known, that the shells of fishes are formed of stony matter oozing out of their body, it is no wonder if that matter when it chances to overflow, bursts forth in any cavity of the body, and forms a little mass, which hardening, becomes a pearl of the same colour with the shell.

Whereas all other animals take in nutriment by the mouth, the muscle takes it in by the anus. The part called the head, though without eyes, ears, or tongue, is immoveably fastened to one of the shells so that it cannot receive any thing. The food of a muscle is water, which, as the shell opens, enters in at the anus, and passing on by certain canals, running between the shell and the animal, is thence conveyed into the mouth.

We have lately discovered a progressive motion in those shell-fish, which were supposed to be quite fixed. Even OYSTERS, which one would think wholly immoveable, if they are thrown irregularly into a vessel of water, will in a while turn themselves till the smooth shell becomes uppermost: otherwise they could hold no water in the concave shell for their sustenance.

Muscles can walk on the ground, which they do in this manner: lying on the flat side of their shell, they thrust out a part, in form of a tongue, wherewith they make little motions to the right and left, and thereby dig a passage in the sand. In this digging they drop gradually on one side, and so get the shell mounted on its edge; then they stretch out the tongue as far as they can, and rest for a minute or two on its extremity to draw the shell after them, as water snails do. This motion is repeated as long as they please; thus they form a sort of groove in the sand, which sustains the shell on either side, and leaves behind them a sort of irregular tract, three or four yards long. In rivers abounding with muscles one may see many of them, with a muscle at the end of each.

That called the arm or a leg in a sea-muscle, which in its natural state is not above two lines long, may reach out of the shell two inches: and the muscle having laid hold on a fixed point therewith, bends and shortens it and so drags itself on. The beard serves for an anchor to fasten to some heavy body, that it may not be carried away with the motion of the waves.

When a pond muscle walks, it thrusts out its whole belly, in form of the keel of a ship, and creeps on the belly as the serpent does. So true it is, that nature is not confined in her manner of operation, but is ever varying, though never confused.

In Port Mahon harbour, there are stones from half a hundred to five hundred weight each, lying at all depths, full of shells, each containing a single fish, of the muscle kind. The holes in the surface

are far narrower than the hole in which the fish is, which it seems is capable of enlarging its room as its grows bigger, by abrading the sides of its cells. And this is apparent, from the sandy matter found in the bottom of those cells, whenever the orifice is higher than the bottom: for then the fish cannot throw it out.

The BOLLANI, likewise in the Adriatic sea, live in large stones. Their shell is rough and oblong, not unlike a date. They are found in several kinds of porous stones. In the pores of these the spawn is deposited. Frequently the aperture, through which it was injected, is no longer perceivable; but the fish thrives notwithstanding. On breaking some of these stones, one finds near thirty live fish, though no opening can be perceived on the outside. Each has just room to open its shell, the inside of which is white, the outside ash colour; the largest is four or five inches long. Both the fish itself and its juices are so luminous, one may see to read by it; and even water, in which it has been squeezed, put into a glass, will shine ten or twelve hours.

Likewise in Toulon harbour are found solid stones, containing, in separate cells, secluded from all communication with the air, several living shell fish. The same are found along the coast of Alcona, in stones weighing fifty pounds and upwards. The outside of which is soft, but the inside so hard as to require an iron mall, and a strong arm to break them.

PHOLADES BOLLANI, when divested of their shells, resemble a roundish, soft pudding, with no instrument that seems in the least fitted for boring into stones, or even penetrating the softest substance. A pholas is furnished with two teeth indeed; but these are placed in such a situation as to be incapable of touching the hollow surface of its stony dwelling. It has also two covers to its shell that open or shut at either end; but these are totally unserviceable to it as a miner. The instrument with which it performs all its operations, and buries itself in the hardest rocks, is only a broad fleshy substance, somewhat resembling a tongue, that is seen issuing from the bottom of its shell. With this soft yielding instrument, it perforates the most solid marbles; and having, while little and young, made its way, by a very narrow passage into the substance of the stone, it then begins to grow bigger, and thus to enlarge its apartment. While yet naked and very small, it has effected an entrance, and has buried its body in the stone: it there continues for life at its ease; the sea-water, that enters at its apertures, supplying it with luxurious plenty. When the animal has taken too great a quantity of water, it is seen to spurt it out of its hole with some violence. Upon this seemingly thin diet, it quickly grows larger, and soon finds itself under a necessity of enlarging its habitation and its shell. The motion of the pholas is slow

beyond conception ; its progress keeps pace with the growth of its body ; and in proportion as it grows larger it makes its way farther into the rock. When it has got a certain way in, it then turns from a certain direction, and hollows downward ; till at last, when its habitation is completed, the whole apartment resembles the bowl of a tobacco pipe : the hole is the shank, being that by which the animal entered.

Thus immured, the pholas lives in darkness, indolence and plenty ; it never removes from the narrow mansion into which it has penetrated ; and seems perfectly content with being enclosed in its own sepulchre. The influx of the sea water, that enters by its little gallery, satisfies all its wants ; and without any other food, it is found to grow from seven to eight inches long, and thick in proportion.

Yet the pholas, thus shut up, is not so solitary an animal as it would at first appear ; for though it is immured in its hole without egress ; though it is impossible for the animal, grown to a great size, to get out by the way it made in, yet many of this kind meet in the heart of the rock, and, like miners in a siege, who sometimes cross each other's galleries, they frequently break in upon each other's retreats : whether their thus meeting be the work of accident or of choice, few can take upon them to determine ; certain it is they are most commonly found in numbers in the same rock ; and sometimes above twenty are discovered within a few inches of each other.

This animal is found in greatest numbers at Ancona in Italy ; it is found along the shores of Normandy and Poitou, in France ; it is found also upon some of the coasts of Scotland, and in general is considered as a very great delicacy at the tables of the luxurious.

One of the most extraordinary kinds of shell-fish is the ANIMAL-FLOWER, in Barbadoes. In the parish of St. Lucy, on the north side of the island, there is a high rocky cliff fronting the sea, near the bottom of which is a large cave. This opens into another cave, the bottom of which is a basin of water. In the midst of this basin is a rock, always covered with water : on the sides of which, a few inches below the water, are seen, at all times of the year, issuing out of little holes, what have the appearance of finely radiated flowers ; in size, colour and shape greatly resembling a common marygold.

If you attempt to pluck one of these, as soon as your fingers come within two or three inches of it, it contracts, closes up its border and shrinks back into the hole of the rock. But if left undisturbed for a few minutes, it issues again, and soon appears in full bloom. This might induce one to believe, that it was no other than an aquatic sensitive plant.

But on a nearer inspection we may discern four dark coloured filaments, rising from the centre, moving with a quick and spontaneous

motion, and frequently closing, to seize its prey, much like the claws of a lobster. So that the seeming flower is really an animal; and its body, which appeared to be the stalk of the flower, is black, about as big as a raven's quill.

It seems the vivid yellow colour of its feelers, is absolutely necessary to procure its food. The water in the cave, having no motion, cannot bring any food to them. Therefore the Creator has endued this creature with a quality which may allure its prey. For bright colours invite many aquatic animals, as the flame of a candle does flies.

12. As to the generation of fishes, some of them are viviparous, others oviparous. The womb and ovaries of most fishes, are not unlike those of birds. The female casts out innumerable eggs, in the sea, in lakes, and in rivers. Great part of these are devoured by the males. The rest are hatched by the warmth of the sun, and the young ones immediately swim away, without any help from the parent.

Sea-tortoises lay their eggs on the sea shore, and cover them with the sand. It is not uncommon to see a great number of young tortoises rise out of the sand, and without any guide or instructions, march with a gentle pace toward the water. But the waves usually throw them back upon the shore, and then the birds destroy the most of them. So that out of two or three hundred of them it is seldom that ten escape.

It seems at first view, that nature, in this instance, charges herself with unnecessary expense. But a little reflection shews the contrary. We do not complain of the fertility of a hen, which frequently lays above two hundred eggs in one year: although it may be, that not one chick is hatched out of all these. The design of the Author of nature is plain: not barely to preserve the species, but at the same time, to provide man and other animals with an excellent food. So his intention in the fertility of a tortoise, is not barely to continue that species, but to accommodate a number of other animals with food convenient for them.

But whence could arise the common opinion concerning the generation of SOLES? Namely, that they are produced from a kind of shrimps or prawns? A French gentleman, being determined to try, put a large quantity of prawns into a tub about three feet wide, filled with sea water. At the end of twelve or thirteen days, he saw there eight or ten little soles, which grew by degrees. He repeated the experiment several times, and always found little soles. Afterwards he put some soles and prawns together, in one tub, and in another, soles alone. In both, the soles spawned; but there were not little soles, only in the tub where the prawns were.

But how can prawns be of use toward producing soles? Farther observations cleared up this. When shrimps or prawns are just taken out of the sea, you may discern between their feet many little bladders, which are strongly fastened to their stomach, by a kind of glue. If you open these bladders gently, you see a sort of embryos, which, viewed with a microscope, have all the appearance of soles.

Now here lies the mystery. These are the eggs or spawn of soles, which in order to hatch, are fastened to the shrimps or prawns: like many plants and animals, which do not grow or receive nourishment, but upon other plants and animals. The prawns therefore are the foster-mothers of soles, during their first infancy. And this has accasioned many to imagine they were their real mothers.

The coming of certain kinds of fish in shoals to certain coasts, at a certain time of the year, is of great advantage to mankind. But the reason of it has been little understood. Yet observation may clear it up. There is a small insect common in many seas, particularly on the coast of Normandy, in June, July, and August. They then cover the whole surface of the water as a scum. And this is the season when the herrings come also in such prodigious quantities. The fishermen destroy much of these vermin; yet to these alone their fisheries are owing. For it is evident the herrings feed on these by the quantities found in all their stomachs. And doubtless the very reason of their coming is to feed upon them. Probably the case is the same in all other places, where the herrings come in the same plenty.

The numberless swarms of herrings, cod, and other fish, that come forth yearly from their shelter, under the ice adjoining the north pole, divide themselves into three bodies. One part direct their course southward toward the British islands; another part westward, toward Newfoundland, and other places in North-America; and the third part along the coast of Norway, and then through the sound into the Baltic.

The water, though quite still before, curls up in waves wherever they come. They croud together in such numbers, that they may be taken up by pailfulls.

A large shoal of herrings, reaches (according to the fishermen's account) a hundred or two hundred fathoms deep. They extend also to a considerable circumference. Were they all to be caught, the greatest part would be lost. For it would be impossible to get hands, tubs, salt, and other necessaries to cure them. Several hundred ship loads are sent every year from Bergen alone to foreign parts: besides the quantities that the peasants at home consume, who make them their daily provision.

The fishers, on the western isles of Scotland, observe, that there

is a large herring, double the size of a common one, which leads all that are in the bay, the shoal following him wherever he goes. This leader they term the king of herrings: and when they chance to catch it alive, they drop it carefully into the sea, judging it petty treason to destroy a fish of that name.

Mackerels come in the same numbers at certain times of the year; and for the same reason. They are particularly fond of a sea plant, the narrow leaved, purple sea-wick, which abounds on the coasts of England; and is in its greatest perfection in the beginning of summer: though at sometimes later than other, according to the severity or mildness of the winter.

The chief occasion of their coming is to feed on this plant. And those who attend to its growing up, would know when to expect the mackerel, better than those who listen for thunder.

But this is not the sole occasion of their coming. The real truth is this. The sea near the pole is the native country of all fish of passage. The ice which continually covers that sea, affords them a safe retreat. Large, voracious fish, want a free air for perspiration, and cannot pursue the smaller sort into their sanctuaries, where they multiply so prodigiously, that at length, for want of subsistence, they are forced to quit their retreat. The large fish wait for them at the extremity of the ice. They devour all they can catch, drive them close into the coasts, while the birds of prey pour down upon them from all quarters. In consequence of this persecution their march is always in columns, which are commonly as thick as they are broad. With regard to the herrings, they quit the ice in the beginning of the year. But the prodigious column which they form soon divides into two wings. The right moves westward, so as to be near Iceland in the month of March. The left bends its course easterly, and comes down the north sea to a certain latitude, where it divides into two other wings, the eastern-most of which coasts along Norway. Hence it sends off one division, by the strait of the sound, into the Baltic, another towards the country of Holstein, Bremen, &c. and thence into the Zuderzee. The western wing, which is the largest, falls directly upon the isles of Shetland and the Orkneys. And thither the Dutch go to wait their coming. All that escape these dexterous fishers, go on to Scotland, and, dividing again into two columns, one passes to the east of that kingdom, and goes round England, detaching numerous divisions to the coasts of Friesland, Holland, Zealand, Flanders, and France, while the other moves to the westward of Scotland and Ireland. The remains of the whole western wing, which have escaped the nets of the fishers, and the voracity of other fish and fowl, having at length rallied in the channel, the column is formed anew, and then issues into the ocean: from which (without

shewing itself again on the coast) it regains, like the remains of the first western wing, which had not travelled so far, the polar ice, at the approach of winter. And under the protection of this, the loss is repaired, which the species had suffered since they left it.

Thus does the divine wisdom supply many thousands of men with food, as well as numberless other animals; and yet prevent any decay of that necessary provision, which is continually consumed and as constantly recruited.

The TUNNIES come in equal shoals at certain seasons, to the coasts of Provence and Languedoc. The fish called by the French, the Emperor, is the great enemy of these fish. He is in summer so plentiful in those seas, that they cannot escape him but by flying to the shallow waters.

The PILCHARDS catched on the coast of Britanny, are still a stronger proof of the natural means that bring fish in shoals to certain places. The people of Britanny purchase from Norway, the offals and entrails of all the large fish caught there. These they cut in pieces, and strew in vast quantities on the sea along the coasts. This always brings thither shoals of pilchards, enough to supply all the maritime places in the neighbourhood.

The SALMON (bred both in the sea, and in rivers) is another fish, which comes in shoals at certain times. But this is on another occasion. The female salmon chiefly ejects her roe at the mouth of rivers, in shallow water. The male comes presently after, keeps other fish from devouring it, and casts his sperm upon the roe. They are in great plenty from the middle of April till the middle of July; at which time also, they come in shoals into the rivers, partly to refresh themselves in fresh water, and partly to rub or wash off in the strong currents, a greenish vermin called salmon lice; insects, wisely designed by the Creator, to drive this rich and valuable fish into the hands of men.

The salmon, when they are going up the rivers out of the sea, always swim as near the bottom as they can. And on the contrary, when they are going down them into the sea, they always swim near the surface. The reason is, in going up, they swim against the current, which always runs swiftest at the surface. When they are going down on the surface, the current alone is sufficient to carry them.

At Leixlip, seven miles from Dublin, there is a fine water-fall, or salmon-leap, so called from the numberless salmon which leap up it, at the season of the year for spawning. When they come to the foot of the fall, you may observe them frequently to leap up just above the water, as if to make an observation of the distance. Soon after they leap up again, with an attempt to gain the top, and perhaps rise near it; but the falling water drives them down again. The same

fish soon springs up again, and rises above the fall: yet this is equally unsuccessful, for dropping with their broadsides on the rapid curvature on the waters, they are thrown back again headlong. The only method of succeeding in their attempts, is to dart their heads into the water, in its first curvature over the rocks. By this means they first make a lodgment on the top of the rock for a few moments, and then scud up the stream. There seems to be a peculiar instinct in them, to aim at this very point; for the force of the stream on the top of the precipice, is less at the bottom, close to the rock than on the surface. It is almost incredible, the height to which they will leap; they frequently leap near twenty feet. The manner of their doing it is, by bending their tails round, almost to their heads; it is then by the strong re-action of their tails against the water, that they spring so much above it.

13. One particular instance of the Divine care, is observable in the TURBOT. He is not well able to swim, especially in stormy weather. He must then keep at the bottom, and stick in the sand. And for that reason, he is provided with a skin or membrane which draws over his eyes, to keep the sand out of them.

WHALES are as many degrees raised above other fishes in their nature, as they are in their size. They resemble beasts in their internal structure, and in some of their appetites and affections. They have lungs, a midriff, a stomach, intestines, liver, spleen, bladder, and parts of generation like beasts. Their heart also resembles that of beasts, driving red and warm blood in circulation through the body.

As these animals breathe the air, they cannot bear to be long under water. They are constrained, every two or three minutes, to come up to the surface to take breath, as well as to spout out through their nostril (for they have but one) the water which they sucked in while gaping for their prey.

The senses of these animals seem also superior to those of other fishes. The eyes of other fishes are covered only with that transparent skin that covers the rest of the head: but in all the cetaceous kinds, they are covered by eye-lids as in man. This keeps that organ in a more perfect state, by giving it intervals of relaxation. The other fishes, that are very staring, must see, if for no other reason, more feebly, as their organs of sight are always exerted.

As for hearing, they are furnished with the internal instruments of the ear, although the external orifice no where appears. It is probable, this orifice may open by some canal into the mouth; but this has not as yet been discovered.

It is likely, that all animals of the kind can hear, as they certainly utter sounds to each other. This vocal power would be as needless to animals naturally deaf, as glasses to a man that was blind.

But it is in the circumstances in which they continue their kind, that these animals shew an eminent superiority. Other fish deposit their spawn, and leave the success to accident; these never produce above one young, or two at the most; and this the female suckles entirely in the manner of quadrupeds, her breasts being placed as in the human kind.

In fishes of the whale-kind, the tail has a different position from what it has in all other fishes. For, whereas, in these it is erected perpendicular to the horizon; in them, it lies parallel thereto; partly to supply the use of the hinder pair of fins, which these creatures have not, and partly that they may be able to raise or depress their body at pleasure. For it being necessary they should frequently come to the top of the water to take in, or let out the air, they are provided with an organ to facilitate their ascent and descent as they have occasion. And, as for turning their bodies in the water, they perform that as birds do; by strongly moving one of their fins, while the other is quiescent.

The Norway whale is frequently sixty or seventy feet long. His shape pretty much resembles that of a cod; he has a large head, and small eyes in proportion. On the top of the head are two openings, through which he spouts out the water (which he takes in as he breathes) like a large fountain, which makes a violent noise.

His skin is smooth and not very thick. The colour of his back is dark and marbled. His belly is white. His throat is very narrow, in proportion to his size. Under his backbone lies a long bladder, which he dilates or contracts as he pleases. He rows himself with his tail. They copulate after the manner of land animals.

The female brings forth but one or two at a birth, at which time they are nine or ten feet long. They suck, for some time; when they are tired with swimming, she carries them between her great fins. Under the skin lies the blubber or fat. Its usual thickness is about six inches: but about the under lip it is found two or three feet thick. Out of this the oil is extracted. One whale ordinarily yields forty or fifty, sometimes eighty or ninety hundred weight.

The use of blubber seems to be partly to poise the body and make it equiponderant to the water; partly to keep the water at a distance from the blood, lest it should be chilled by its immediate contact; and partly to keep the fish warm, by reflecting the hot steams of the body, and so redoubling the heat.

Under the fat the flesh is of a reddish colour. Their general food is certain small insects, which float upon the water in great heaps, and are no larger than flies. But they likewise eat various sorts of small fish, particularly herrings, which they drive together in large shoals, and then swallow vast quantities, at a time. The whale commonly goes under the shoal: then opens his mouth and sucks in all he can.

Sometimes he swallows so many, that he is ready to burst, and sets up a hideous roar.

But he is far more troubled by a slender fish about four feet long, which tears great pieces of flesh out of him.* The whale then not

* One would be inclined to imagine from the size, strength, activity, and general character of the whale, that he would answer the same description in his native element, as the lion among the beasts, and the eagle among the birds; and that he might be emphatically termed the king of fishes, and sovereign of the ocean; but notwithstanding his enormous bulk, and incomparable strength, he has to contend with some formidable enemies: among which the swordfish seems to be his most natural, and serious adversary. This terrible inhabitant of the ocean will hunt up the whale, and spying him at a distance above him near the surface, will dart with incredible velocity, and strike his sword into the body of the whale several feet, and inflict a mortal wound, or if the whale happens to spy him in his approach, he will fly from him with the utmost terror. At the sight of this little animal, says Mr. Anderson, the whale seems agitated in an extraordinary manner, leaping from the water as if with affright. If the whale perceives it at a distance, it flies from it in the opposite direction. I have been myself, continues he, a spectator of their terrible encounter, the whale has no instrument of defence, except its tail, with that it endeavours to strike it's enemy; and a single blow would be sufficient to effect its destruction: but the swordfish is as active as the whale is strong, and easily avoids the stroke; then bounding into the air, it falls upon its great subjacent enemy, and endeavours, not to pierce it with its pointed beak, but to cut it with its toothed edges. The conflict is dreadful, beyond imagination, and the sea is seen all around died in blood, proceeding from the wounds of the whale, while the enormous animal vainly endeavours to reach its invader, and strikes with its tail against the surface of the water, making a report at each blow louder than the noise of a cannon. The terrible conflict continues till the whale, becoming weak with the loss of blood, his adversary completes the work of destruction at his leisure.

The amazing force of this fish cannot be better exhibited than by the recital of an extraordinary occurrence, which took place on board a large ship which arrived at the port of Philadelphia some years ago; this ship had sprung aleak some distance out at sea, at the commencement of which the people on board felt a very sensible shock, as if the vessel had just struck upon the point of a rock, or upon some old wreck, and which they thought must have been the case. The leak continued to gain upon them, but by exertion at the pumps, the ship was brought safe into port. On taking out the cargo, they found the cause of the leak, and of the shock. It was the sword of a fish which had pierced through the bottom several feet, and which was broken off at the base. It would seem as if the fish had mistaken the ship for a whale, or some other subject of prey, and made its accustomed blow to wound it.

The whale has to contend with other enemies besides the sword: it is said the orca or grampus, is a great enemy of the whale, and will fasten on it like a dog on a bull, and worry it till the creature roars out with pain. This fish has thirty teeth in each jaw which are so constructed, and fit together in such a manner, as to enable it to take a very fast hold on any thing it seizes. Some say it will even destroy the whale and prey upon it.

There is another small animal of the shell kind, called the whale louse, which is a great pest to the creature, which sticks to its body, as we see shells sticking to the foul bottoms of ships on their return from long voyages. This insinuates

only makes a frightful noise, but often leaps a considerable height. In these leaps he sometimes raises himself perpendicular above the surface of the water, and then plunges himself down with such violence, that if his head strikes any of the hidden rocks that are in the shallows, he fractures his skull, and comes instantly floating up dead. So that there is no creature in the world so great or strong as to be exempt from calamities!

The whalebone whale is about seventy feet long, and very bulky, having scales, and no fins, but only one on each side, from five to eight feet long.

The spermaceti whale is much of the same dimensions. The spermaceti oil lies in a great trunk, four or five feet deep, and ten or twelve feet long, near the whole length, breadth and depth of the head. It seems to be no other than the brain. Not but some other parts of the fish yield an oil, but not so good as that in the trunk. The care of their young is remarkable: while they carry them under water, they often rise for the benefit of the air. Whenever they are chased or wounded, as long as they have sense, and perceive life in their young, they will not leave them, and if in their flying the young one drops off, the dam comes about, and passing underneath takes it again.

Whales are gregarious, being sometimes found a hundred in a swarm, and are great travellers. In autumn the whalebone whales go westward: in spring eastward again. The several kind of whales do not mix with each other, but each keep by themselves.

Their wonderful strength lies chiefly in the tail. A boat has been cut down from the top to the bottom by the tail of a whale, and the clap boards entirely splintered, though the gunnel on the top was of tough wood. Another has had the stern post, three inches thick, cut off smooth without so much as shattering the boat, or drawing the nails of the boards.

It is commonly supposed, that all fishes are mute, as well as void of hearing. But a late author says, there is one kind of whale, that when they are struck, roar so loud as to be heard two miles. He

itself chiefly under the fins, and whatever efforts the great animal makes to free itself, it still keeps its hold, and lives upon the fat, which it is provided with instruments to arrive at.

Whales have been met with in the torrid zone of an enormous size; one measured 180 feet in length, and was of correspondent bulk. It is an observation lately made, that the number of whales is considerably diminished, in consequence of the great devastation made on the species by the great number of whale ships fitted out from all nations, and which traverse all seas. The principal whale fishery is now reckoned to be in the seas contiguous to the Faukland islands, in the Pacific Ocean.

likewise asserts, that some of them have hearing, as have snakes and all the lizard kind, though they have not the usual outward apparatus of hearing. But they have the auditory passage, by which sound is conveyed, and internal organs, to which the *meatus auditorious* reaches. This is observable in all the whale kind, and in all fishes that have lungs. And whereas, some have supposed, that water cannot transmit sound, the contrary of this is now well known. Many experiments have shewn, that even a man under water may hear what is spoken in the open air.

The HIPPOPOTAMOS, or river horse, is above seventeen feet long from the snout, to the insertion of the tail; above seven feet in circumference round the body, and above seven feet high: the head is near four feet long, and above nine feet in circumference. The jaws open about two feet wide, and the cutting teeth, of which it hath four in each jaw, are above a foot long.

Its feet resemble those of the elephant, and are divided into four parts. The tail is short, flat and pointed; the hide is impenetrable to the blow of a sabre; the body is covered over with a few scattered hairs of a whitish colour. The figure of the animal is between that of an ox and a hog, and its cry between the bellowing of the one, and the grunting of the other.

It chiefly resides at the bottom of the great rivers and lakes of Africa; the Nile, the Niger, and the Zara; there it leads an indolent life, seldom disposed for action, except when excited by the calls of hunger. Upon such occasions, three or four of them are often seen at the bottom of a river, forming a kind of line, and seizing upon such fish as are forced down by the violence of the stream. In that element they pursue their prey with great swiftness and perseverance; they swim with much force, and remain at the bottom for thirty or forty minutes without rising to take breath. They traverse the bottom of the stream, as if walking upon land. But it often happens, that its fishy food is not supplied in sufficient abundance; it is then forced to come upon land, where it is an awkward and unwieldly stranger; it moves but slowly, yet it commits dreadful havoc among the plantations of the helpless natives, who see their possessions destroyed, without daring to resist their invader. Their chief method is, by lighting fires, striking drums, and raising a cry to frighten it back to its favourite element. But if they happen to wound it, it then becomes formidable to all that oppose it: overturning whatever it meets. It possesses the same inoffensive disposition in its favourite element, that it is found to have upon land; it never attacks the mariners in their boats, as they go up or down the stream; but should they inadvertently strike against it, there is much danger of its sending them at once, to the bottom: "I have seen, says a

mariner, one of these animals open its jaws, and seizing a boat between his teeth, at once, bite and sink it to the bottom. I have seen it upon another occasion, place itself under one of our boats, and raising under it, overset it with six men which were in it; who, however, happily received no other injury." Such is the great strength of this animal: and from hence, probably, the imagination has been willing to match it in combat against others more fierce and equally formidable. The crocodile and shark have been said to engage with it, and yield an easy victory: but as the shark is only found at sea, and the hippopotamos never ventures beyond the mouth of fresh water rivers, it is most probable that these engagements never occurred; it sometimes happens, indeed, that the princes of Africa, amuse themselves with combats, on their fresh water lakes, between this and other formidable animals; but whether the rhinoceros or the crocodile are of this number, we have not been particularly informed. If this animal be attacked by land, and finds itself incapable of vengeance, from the swiftness of its enemy, it immediately returns to the river, where it plunges in head foremost, and after a short time rises to the surface, loudly bellowing, either to invite or intimidate the enemy; but though the negroes will venture to attack the shark, or the crocodile, in their natural element, and there destroy them, they are too well apprized of the force of the hippopotamos to engage it: this animal, therefore, continues the uncontrouled master of the river, and all others fly from its approach or become an easy prey.

As the hippopotamos lives upon fish and vegetables, so it is probable the flesh of terrestrial animals may be equally grateful: the natives of Africa assert, that it has often been found to devour children and other creatures that it was able to surprise upon land; yet as it moves slowly, almost every creature, endued with a common share of swiftness, is able to escape it; and this animal, therefore, seldom ventures from the river side; but when pressed by the necessities of hunger, or of bringing forth its young.

The female always comes upon land to bring forth, and it is supposed that she seldom produces above one at a time; upon this occasion, these animals are particularly timorous, and dread the approach of a terrestrial enemy; the instant the parent hears the slightest noise, it dashes into the stream, and the young one is seen to follow it with equal alacrity.

The young ones are said to be excellent eating; but the negroes, to whom nothing that has life comes amiss, find an equal delicacy in the old. Dr. Pocock has seen their flesh sold in the shambles like beef; and it is said, that their breast in particular, is as delicate eating as veal. These animals are found in great numbers, in Africa and India, and as they produce very fast, their flesh might supply the

countries where they are found, could those barbarous regions produce more expert huntsmen.* But this creature, which once was in such plenty at the mouth of the Nile, is now wholly unknown in Lower Egypt, and is no where to be found in that river, except above the cataracts.

*This wonderful animal is the Behemoth of Job described in chap. xl. ver. 15—24. where its manners, food, and haunts, are admirably described. In some parts it is hunted for its meat, which is not unsavory, and is esteemed wholesome. One method of destroying it, is to place a quantity of dried pease, in a place where it is known to frequent, of which it will devour such a quantity, as to produce immoderate thirst, to appease which it returns to the water, and drinking largely, the pease will swell, and burst the animal. Mr. Sparman once engaged in an expedition to hunt this animal; "the same night, continues he, we betook ourselves again to our posts; and at half past eight, it being already very dark, one of them began at intervals to put its head above water, and utter a sharp, piercing, and very angry cry. At eleven o'clock we could plainly hear one near our encampment, nibbling the boughs which hung over the water, and devouring the short grass, and low shrubs which grew on the bank. It did not however approach near enough for attack that night. We passed the following night at the same posts, when it advanced and acted as on the former night. The next morning after sunrise, just as we were thinking of going home to our waggons, to our surprise, there came a female hippopotamos with her calf, probably from some other river, to take up her quarters in that which we were blockading. While she was waiting at a rather steep part of the river's banks, and looking back after her calf, which was tame, and came on but slowly, she received a shot in her side, upon which she directly plunged into the river, but was not mortally wounded. This shot however, was so far of service, that one of the Hottentots ventured to seize the calf, which he held by the hind legs, till the rest of the hunting party came to his assistance, upon which the calf was fast bound, and with the greatest joy borne in triumph to our waggons. But while we were taking it over a shallow, near the river, the Hottentots were very much alarmed, lest the wounded mother, or some other of the hippopotamoses, should be induced by the cries of the calf to come to its rescue. The creature, while it was bound, made a noise much like a hog, that is going to be killed; or that has got fast between two posts. It demonstrated great strength in the attempt it made to get loose, and was quite unmanageable, and unwieldly. The length of it, was three and a half feet, and its height two feet. It was supposed about a fortnight, or at most three weeks old At length we turned it loose, and it ceased crying, but not till after the Hottentots had rubbed their hands several times over its nose, to accustom it to their effluvia, after which it became reconciled. Some time after this, it was killed, dissected, and eaten up, in less than three hours time, the reason of which, was partly owing to the hot weather, and partly our being in absolute want of any other fresh provisions. The flesh and fat, was flabby, as might be expected for want of age, and consequently, not near so good as the old hippopotamoses, the flesh of which is tender, and the fat of a taste like marrow. On this account, the natives look upon the flesh and fat of this creature as the wholesomest meat that can be eaten, particularly the glutinous part of the feet, when properly dressed, is accounted a great delicacy. The dried tongues of these animals are also considered, even at the cape, as a rare and savoury dish. One of these tongues, presented to the king of Sweden, was near three feet in length, and very blunt and thick at the end."

One can hardly tell whether to rank him among land or water animals. He sleeps on land, but passes almost all the rest of his time under water, where he principally feeds. He comes out of the water in the evening to sleep: and when he goes in again, he walks very deliberately in overhead, and pursues his course along the bottom, as easy and unconcerned as if it were the open air. The rivers he most frequents are very deep, and where they are clear, this affords an astonishing sight.

An animal of this size and make, must be one of the strongest in the world. It therefore requires from nature no swiftness, either to avoid pursuit, or to overtake its prey, as it was designed to feed chiefly on vegetables. The manner of its feeding on them is this: when he walks into the river, he seldom looks about till he is near the middle. Here he seeks for the larger water-herbs, particularly for the root of a large water-lilly. People from a boat on the surface, frequently see this. He roots up these with his nose, like a hog, and his mouth and throat being very wide, swallows them up in vast morsels half chewed.

But he has frequently occasion to breathe: in order to which, when feeding at his ease, his custom is, every thirty or forty minutes, to rise to the surface of the water. This he does, by a spring from the bottom, made with all his feet at once. Having taken a little fresh air, and looked about him, he drops to the bottom again.

Of all the inhabitants of the deep, those of the SHARK-kind, are the most voracious. The smallest of this tribe is not less dreaded by greater fish, than many that seem more powerful; nor do any of them seem fearful of attacking animals far above their size. But the great WHITE SHARK joins to the most amazing rapidity, the strongest appetites for mischief; as he approaches nearly in size to the whale, he far surpasses him in strength and celerity, in the formidable arrangement of his teeth, and his insatiable desire of plunder.

The white shark is found from twenty to thirty feet long. Some assert, that they have seen them of four thousand pounds weight. The mouth is enormously wide; as is the throat, and capable of swallowing a man with great ease. But its furniture of teeth is still more terrible: of these there are six rows, extremely hard, sharp pointed and of a wedge-like figure. It is asserted, there are seventy-two in each jaw; one hundred and forty-four in the whole. With these the jaws, both above and below, are planted all over, but he has a power of erecting or depressing them at pleasure. When the shark is at rest, they lie quite flat in his mouth: but when he prepares to seize his prey, he erects all his dreadful apparatus, and the animal he seizes dies, pierced with a hundred wounds in a moment.

His skin is rough, hard and prickly, being that substance which covers instrument cases, called shagreen.

No fish can swim so fast as he; he outstrips the swiftest ships, plays round them, darts out before them, and returns to gaze at the passengers. Such amazing powers, with such great appetites for destruction, would quickly unpeople even the ocean; but providentially the shark's upper jaw projects so far above the lower, that he is obliged to turn on one side, not his back, as is generally supposed, to seize his prey. As this takes some small time to perform, the animal pursued often seizes that opportunity to escape.

Tortoises are commonly known to exceed eighty years old; and there was one kept in the arch-bishop of Canterbury's garden, at Lambeth, that was remembered above a hundred and twenty. It was at last killed by the severity of the frost, in its winter retreat, which was a heap of sand, at the bottom of the garden.

The young tortoises are generally excluded in about twenty-six days. The little animals no sooner leave the eggs than they seek for their provision; and their shell with which they are covered from the beginning, expands and grows larger with age. As it is composed of a variety of pieces, they are capable of extension at their sutures, and the shell admits of increase in every direction. It is otherwise with those animals, whose shell is composed all of one piece, that admits of no increase: which, when the tenant is too big for the habitation, must burst the shell, and get another. But the covering of the tortoise grows larger in proportion as the interior parts expand; in some measure resembling the growth of the human skull, which is composed of a number of bones, increasing in size, in proportion to the quantity of the brain. All tortoises therefore, as they never change their shell, must have it formed in pieces: and though in some these marks have not been attended to, yet doubtless they are general to the whole tribe.

It is of different magnitudes, according to its different kinds; some turtles not being above fifty pounds weight, and some above eight hundred.

The great MEDITERRANEAN TURTLE is the largest of the turtle-kind, with which we are acquainted. It is found from five to eight feet long, and from six to nine hundred pounds weight.

All tortoises, having small and weak feet, are exceeding slow in their motions. They have neither tongue nor teeth, nor any offensive weapon. How then can they take, how can they chew or in any degree comminute their food? This is well provided for: they break not only shells, but sometimes even stones with their lips: which, by their excessive hardness, effectually supply the want of teeth. But how can they defend themselves? Abundant provision is made for this also. Their shells more than cover the

whole body, and are of so firm a texture, that a loaded waggon may go over them, without any injury either to the shell or the creature within it.

The blood of the tortoises is colder than any common spring water; yet is the beating of the heart as vigorous as that of any animal, and the arteries as firm as those of any creature.

There is something highly remarkable in the change of tadpoles into frogs; but there is still something more remarkable in the FROG-FISH. These are found in great numbers in the river Surinam. At first they are perfect frogs, they are spotted with brown, yellow, and green; but are paler on the belly, their hinder feet are webbed, like those of a goose, the fore feet without webs. The first change the animal undergoes, is by the growing of a tail. After this the fore feet decrease, and perish by degrees. The decrease of the hinder legs follows, and at last the frog is changed into a perfect fish.

It may not be unacceptable or unprofitable to those who see God even in his lowest works, to add a short account of a few more inhabitants of the waters.

FLYING-FISH are very rarely a foot long. They have a pretty large, though thin and light head. The mouth is generally open; the body small, roundish, and tapering towards the tail; besides the usual fins, they have under their necks, three broad and pretty long ones, of a more subtle structure, nearly as thin as a fly's wing, but strengthened with rows of bones. On the back part of their neck they have also a flying fin, about six inches long, quite erect; and lower down the back, there is another shorter, but broader. These wings they use to escape the pursuit of creatures too powerful for them. They rise several feet above the water, and fly the length of two or three musket-shot. Then they drop, because their wings are dry, which serve them no longer than they are moist.

The INK-FISH, as some call it, has a still more extraordinary way of escaping its pursuers. "I have lately," says the author of the Natural History of Norway, "procured a dried one, which is two feet long. The body is almost round, resembling a small bag, and is blunt at both ends. But the head is the most remarkable part. It has two large eyes, and a mouth like a bird's beak. Above this stand eight horns, like a star. Each horn is octangular, and covered with many small, round balls, something larger than a pin's head. On each side of the body there are two skinny membranes, with which he can cover himself all over. The fore part of the body is quite filled with a black fluid. When it is pursued, it discharges this, which colours the water all around, and renders it invisible. This is a wonderful gift of nature, for the preservation of an animal, otherwise utterly helpless."

The ARBORESCENT STAR-FISH is another of the curiosities of nature. It is upwards of a foot in diameter, having its mouth in the middle. The figure of the trunk is pentangular, and from the five angles arise as many branches, which subdivide into several others, and those again into others, that are less, till the last are scarce thicker than horse-hairs, and in number above a thousand. In swimming he spreads all these branches like a net; and when he perceives any prey within them, draws them in again, and so takes them with all the dexterity of a fisherman.

Full as surprising a creature is the TORPEDO, a flat fish, much like a thorn back. It is common on the coast of Provence, and is eaten without any ill effect. But upon touching it with the finger, the person commonly, though not always, feels an unusual, painful numbness, which suddenly seizes him up to the elbow, and sometimes up to the shoulder. It resembles, but far exceeds, the pain felt by striking the elbow violently against a hard body. But it lasts only a few moments, and gradually wears away. If a man touch it with a stick he feels a little of it; if he presses his hand strongly against it, the numbness is the less. But it is so uneasy as to oblige him very speedily to let it go. Many have attempted to account for this; but should we not rather honestly own our ignorance?

The SEA-NETTLE, so called, is another strange production of nature, common, I suppose, in all the northern seas. It generally swims to the top of the water, and is throughout soft, smooth, and transparent. It appears to be a lump of slime or jelly. But it coheres firmly together, being marked in the middle with a cross somewhat like a flower-de-luce.

These creatures are blue, white, or red, and some of them have many branches underneath. These are usually something larger than the common sort, and are of a dark red. They all abound with a corrosive poison, which if it drop on any part of the body will cause a smart and an inflammation, much like that produced by nettles. Hence it has its name. However it is no vegetable, but evidently a living creature. For it has sensation: it grows, moves to and fro, contracts and extends itself. It often picks up and devours small fish, and is itself devoured by others.

The care of the Creator is observable, even in so inconsiderable a creature as a LIMPET, a small shell-fish, which so fastens itself to the rock, that scarce any thing can unloose its hold.

The fact has long been known. But the manner of its fastening itself, was not understood till very lately. Its shell approaches to the figure of a cone; the base of which is occupied by a large muscle, which alone has nearly as much flesh in it, as the whole body of the fish. This is not covered by the shell, but serves the creature

equally to move forward or to fix itself to the rock. When it is in a state of rest, which is the common case, it applies this muscle every way round to the surface of some stone, and thereby holds itself fixt to it so firmly, that it is impossible to take it off with the hands.—Those who would remove them are obliged to make use of a knife for that purpose. And even then it is not easy: for on whatsoever side the blade of the knife attempts to enter, the fish immediately fixes its muscle with double force to the stone.

The true cause of his adhesion is a viscous juice, a kind of glue, thrown out by this muscle, which though it is not perceptible to the eye, yet it is easily perceived by the touch. For if immediately after the removing a limpet from the stone, the finger be applied to the place, it is fastened very strongly to it, by means of the glue left there. But if any wet have come upon the stone, since the fish has been removed, no viscosity can be perceived on it, the whole substance of the glue being immediately dissolved. This consideration may lead us to observe the great care of nature over all her works. How eminently is it manifested in this little fish! It was absolutely necessary for its preservation, that it should have a power of fixing itself to the stone, or it would have been washed away by every wave. And this power is given it, by means of that glue which fixes it so firmly. But when it is fixed, how shall it be loosed? This is equally necessary. For if there be not some power in the animal itself, to dissolve this glue, it must needs perish for want of food, when once fixt to a barren spot. Water is the proper dissolvent of this glue. But it cannot be the external water. This is kept at a distance, by the close adhesion of the outer rim of the great circular muscle. And it is needful it should; else it would always dissolve the glue, as soon as it was discharged. But the under surface of the body of the animal is covered all over with small tubercles, most of which contain water. When, therefore, it would move, it has only to discharge a small quantity of this water, and the cement immediately dissolves and sets it at liberty. The other tubercles doubtless contain the viscous matter. So that, when the animal would fix itself, it needs only to squeeze one set of its tubercles; and when it would loose itself, the other.

14. Upon the whole, how natural are the reflections, which a late writer makes on the inhabitants of the water!

What an abundance of fish do the waters produce! In these I seem to discern nothing but a head and a tail! They have neither feet nor hands. Nor have they any neck: so that their head cannot be turned at all, any otherwise than by turning the whole body. Were I to consider their figure only, I should think they were destitute of all that was necessary for the preservation of their life. But with

these few outward organs they are more nimble and dexterous, than if they had several hands and feet. And by the use they make of their tail and fins, they are carried along like arrows.

But as almost all fishes prey upon each other, and cannot sustain their own lives, any otherwise than by continually destroying those of their own species, how can the inhabitants of the water subsist? How can many species escape utter destruction? God has guarded against this, by multiplying them in so prodigious a manner. More than three hundred thousand eggs have been counted in the roe of a single salmon. By this means, let them be destroyed ever so fast, still their increase is equal to their consumption.

But who can explain how the inhabitants of the sea enjoy their perfect health, in the midst of water so loaded with salt? And by what art is it, that they preserve, even there, a flesh that has not the least taste of it?

Why do those, which are fittest for the use of man, come and offer themselves on our coasts: while so many that would be useless, if not pernicious, affect remoteness from us?

Why do several of them, in their stated seasons, run up into our rivers, and communicate the advantages of the sea, to such countries as are far distant from it? What hand conducts them with so much care and goodness but thine, O thou Preserver of men!

CHAPTER IV.

OF REPTILES.

1. NOT far removed from fishes are REPTILES, so named from their creeping, or advancing on the belly. Many species of them have legs and feet, but very small in proportion to the body. There is a world of contrivance in their motion. The whole body of the earth-worm, for instance, is a chain of annular muscles, or rather one continued spiral muscle, the orbicular fibres whereof being contracted, make each ring narrower and longer, by which means it is enabled, like the worm of an auger, to bore its passage into the earth. Its creeping may be explained by a wire, wound round a cylinder. If this is taken off, and one end extended and held fast, it will bring the other near it. So the worm having shot out its body, which is spiral, takes hold by its small feet, and so brings on the hinder part. Its feet are placed in a four-fold row, the whole length of the worm. With these, are so many hooks, it fastens to the earth, or whatever it

creeps over, sometimes this, sometimes that part of the body, and stretches out, or draws after it another.

2. The most eminent species of reptiles are SERPENTS, which we may therefore particularly consider. Their bodies are of a very peculiar make, having a compages of bones articulated together.—Here part of the body is applied to the ground, and the other part shot forward, which being applied to the ground in its turn, brings the other after it. The spine of their back variously writhed, helps their leaping, as the joints of the feet in other animals. They make their leaps by means of the muscles that extend the folds thereof.

The number of joints in the back-bone are numerous beyond what any one would imagine. In the generality of quadrupeds they amount to not above thirty or forty. In the serpent kind, they amount to a hundred and forty-five from the head to the vent, and twenty-five more from that to the tail. The number of these joints must give the back bone a surprising degree of pliancy: but this is still increased by the manner in which each of these joints is locked into the other. In men and beasts the flat surfaces of the bones are laid one upon the other, and bound tight by sinews; but in serpents the bones play one within the other like ball and socket, so that they have a full motion upon each other in every direction. Thus if a man were to form a machine composed of so many joints as are in the back of a serpent, he would find it no easy matter to give it such strength and pliancy at the same time. The chain of a watch is but a bungling piece of work in comparison.

Though the number of joints in the back-bone is great, yet that of the ribs is still greater; for, from the head to the vent, there are two ribs to every joint, which makes their number two hundred and ninety in all. These ribs are furnished with muscles, which being inserted into the head, run along to the end of the tail, and give the animal great strength and agility.

The skin also contributes to its motions, being composed of a number of scales united to each other by a transparent membrane, which grows harder as it grows older, until the animal changes, which is generally done twice a year. This cover then bursts near the head, and the serpent creeps from it, by an undulatory motion, in a new skin, much more vivid than the former. If the old slough be then viewed, every scale will be distinctly seen like a piece of net work.

There is much geometrical neatness in the disposal of the serpent's scales, for assisting the animal's sinuous motion. As the edges of the foremost scales lie over the ends of the following, so these edges, when the scales are erected, which the animal has a power of

doing in a small degree, catch in the ground, like the nails in the wheels of a chariot, and so promote and facilitate the animal's progressive motion. The erecting these scales is by means of a multitude of distinct muscles, with which each is supplied, and one end of which is tacked each to the middle of the foregoing.

Serpents differ very widely as to size. The LYBOIJA of Surinam, grows to thirty-six feet long. The little serpent at the Cape of Good Hope is not above three inches, and covers whole sandy deserts with its multitudes! This tribe of animals, like that of fishes, seems to have no bounds put to their growth. Their bones are in a great measure cartilaginous; and they are consequently capable of great extension; the older, therefore, a serpent becomes, the larger it grows; and as they live to a great age, they arrive at an enormous size. Leguat assures us, that he saw one at Java, that was fifty feet long.

Vipers are often kept in boxes for six or eight months without any food whatever; and there are little serpents sometimes sent over to Europe, from Grand Cairo, that live for several years in glasses, and never eat at all, nor even stain the glass with their excrements. Thus the serpent tribe unite in themselves two very opposite qualities; wonderful abstinence, and yet incredible rapacity.

Serpents will swim a long time, but they cannot stay long under the water, without being suffocated. In winter they retire under stones, roots of trees, old walls, or any warm, dry shelter. Here they sleep half dead, though with their eyes open, till the returning sun recalls them to life.

3. Their BRAIN little differs from that of fishes: but their stomach very much. It is like a loose gut, which runs along, from the jaws quite to the tail. They have likewise solid ribs and vertebre, at small distances, from the neck to the end of the tail. Hereby they are enabled, to raise themselves up, to support, to writhe themselves into rings, to spring forward, and to suck or swallow any thing with surprising force. And their whole flesh is of so close and firm a texture, that they will live for some time, even after they are cut in pieces. There is nothing more harmless than the common snakes: they are as innocent as flies.

There is a great deal of geometrical nicety in the sinuous motion of serpents. For the assisting herein, the annular scales under their body, are very remarkable, lying across the belly, contrary to those in the back and the rest of the body. Also the edges of the foremost scales, lie over the edges of the following scales from head to tail. So that when each scale is drawn back, or set a little upright by its muscle, the outer edge of it is raised a little from the body, to lay hold on the earth, and to promote the serpent's motion. But

there is another admirable piece of mechanism, that every scale has a distinct muscle, one end of which is fixed to the middle of its scale, the other to the upper edge of the next scale. There is nothing peculiar in the generation of serpents, most of which are oviparous.

4. Vipers and many other serpents have small bags near the root of their teeth, which contain the POISON. When they bite, this is squeezed out, by the compression of those bags. If they are taken out of a viper, the liquid they contain, mixed with the blood of an animal, causes death. But if taken in by the mouth, it does no harm, losing its efficacy by mixing with other liquids.

A viper has the biggest and flattest head of all the serpent kind. It is usually half an ell long and an inch thick, with a snout not unlike that of a hog. It has sixteen small teeth in one row: beside two large, sharp, hooked, hollow, transparent teeth, placed at each side of the lower jaw. These convey the poison into the wound, through a long slit. They are flexible, and then only raised, when the viper is going to bite. The roots of them are encompassed with a little bladder, containing a large drop of yellow insipid juice. The slit is a little below the point of the teeth, which are not hollow to the top. Hence arise all those dreadful symptoms, which frequently end in death. But they are all prevented or removed, by rubbing oil upon the wound.

Vipers creep but slowly, and never leap or bite, unless provoked. They are of a yellowish colour, speckled with longish brown spots. The belly is of the colour of well polished steel. Other serpents lay eggs; but the female viper only brings forth her young alive, wrapt up in skins, which break on the third day, and set them at liberty.

The venom of a viper is not mortal to a sound and robust body, though attended with painful swellings, violent vomitings, frensies, and convulsions. In eight or ten days, the poison having run through divers parts of the body, throws itself into the scrotum, and swelling it extremely, causes great heat, and much urine, very hot and sharp, by which it is discharged, this being the certain crisis of the disease.

But a sickly or fearful person, bit by a viper, surely dies, if there be not speedy help. Any one bit, in two or three days weighs almost as much more as he did before. Who can account for this?

It is remarkable, that the youngest vipers are provided with poisonous teeth grown to perfection, commensurate with their bulk; that so they may be able to kill their prey and feed themselves, as soon as they are born.

The poison of a rattle-snake is equally fatal and more swift in its operation; for it frequently kills within an hour. The snake is in

some places fifteen feet long.* But whenever it moves in order to bite, the tail begins to rattle: and that considerably loud; so that a man, if he has presence of mind, may easily get out of its way. When it bites a hare, he is observed to lick her all over before he takes her into his mouth: probably, that having moistened and smoothed her skin, he may the more easily swallow her.

It is very remarkable, that he frequently stays under a tree, on which a bird or squirrel is hopping about, with his mouth wide open. And the event constantly is, the creature in a while drops into it. Sir Hans Sloane thinks, he has wounded it first: and that he then waits under the tree till the poison works, and the animal drops down into the mouth of its executioner.

But this is not the case, as plainly appears, from what many have been witnesses of. A swallow, pursuing his prey in the air, if he casts his eye on a snake beneath him, waiting with his mouth wide open, alters his course, and flutters over him in the utmost consternation, till sinking gradually lower and lower, he at last drops into his mouth.

To the same purpose is the famous experiment of Dr. Sprenger, mentioned in the Hamburgh magazine. He let loose a mouse on the ground, at a little distance from a common snake. It made a few turns, and squeaked a little, and then ran directly into the mouth of the snake, which all the while lay still and without motion.

The rattle-snake, being less nimble than others, would find difficulty in getting its prey, were it not for the singular provision made by the rattle in his tail. When he sees a squirrel or bird on a tree, he gets to the bottom, and shakes this instrument. The creature looking down, sees the terrible eye of the snake bent full upon it. It trembles, and never attempts to escape, but keeps its eye upon the destroyer, till tired with hopping from bough to bough, it falls down, and is devoured. Indeed the same power is in the viper. The field-mice, and other animals, which are its natural food, if they have once seen his eyes, never escape, but either stand still or run into its mouth.

But vipers in general will not eat, after they are under confinement. The viper-catchers throw them together into great bins, where they live many months, though they eat nothing. It is only a female viper, when big with young, that will eat during its confinement. If a mouse be thrown into the bin, at the bottom of which forty or fifty vipers are crawling, among which one is with young, she alone will meddle with it, and she not immediately. The rest pass it by, without any regard, though it be their natural food. But the female, after she has done this several times, will at length begin to

* The American rattle-snake is seldom more than four feet in length.

eye it. Yet she passes by it again, but soon after stops short, and holding her head facing that of the mouse, seems ready to dart at it, which however she never does, but opens her mouth, and brandishes her tongue. Her eyes having now met those of the mouse, she never looses sight of it more; but they face one another, and the viper advances with her open mouth, nearer and nearer, till without making any leap, she takes in the head, and afterward the whole body.

A common snake will avoid a man; but a rattle-snake never turns out of the way. His eye has something so terrible in it, that there is no looking steadfastly at him. But he creeps very slow, with his head close to the ground, so that one may easily get out of his way. His leaping is no more than uncoiling himself, so that a man is in no danger, if he is not within the length of the snake. Neither can he do any harm, unless he first coil, and then uncoil himself; but both these are done in a moment.

The noise they make is not owing, as some imagine, to little bones lodged in their tails. But their tail is composed of joints that lap over one another, like a lobster's, and they make that noise by striking them one upon another. This is loudest in fair weather; in rainy weather they make no noise at all. It is remarkable, that whenever a single snake rattles, all that are within hearing rattle in like manner.

Of how extremely penetrating a nature is their poison!* A man provoking one of them to bite the edge of his broad-axe, the colour

* The cerastes or horned viper of Abyssinia, is perhaps the most poisonous among reptiles; the operation of its poison is so instantaneous, as to kill in a few minutes. Mr. Bruce relates in his travels in Africa, an occurrence of a singular nature, by which it appears that this deadly animal is not prone to bite, but that on the contrary it exhibits a temper of placidness and sociability to man, he says, the slave of Shekh Adelan, prime minister of Sennaor, brought a cerastes which he had just then brought out of a hole, and handled it with the utmost familiarity. I told him my suspicion, says our author, that the teeth had been drawn, but he assured me that they had not, as did also his master Kittou, who took it from him, wound it round his arm, and at my desire, ordered the servant to carry it home with me. I took a chicken by the neck, and made it flutter about him: his seeming indifference immediately left him, and he bit it with great signs of anger: the chicken died almost immediately.

Another instance he relates which is more astonishing, and which may be seen almost every day at Cairo, without trouble or expense. A man who came from above the catacombs, took a cerastes, from a number of others lying at the bottom of a tub, and put it upon his bare head, covered it with the common red cap he wore, took it and put it in his breast, then tied it round his neck like a necklace, and handled it with unbounded familiarity; after which it was applied to a hen; the viper bit it, and the hen died in a few minutes: but to complete the experiment, the man took the venomous reptile by the neck and beginning at the tail

of the steeled part presently changed; and at the first stroke he made with it in his work, the discoloured part broke out, leaving a gap in the axe.

A gentleman in Virginia has lately given a particular account of what he felt after being bit by one of them.

"Hearing," says he, "a bell upon the top of a steep hill, which I knew to be on one of the cows of the people where I then quartered, I went right up the hill; but near the top my foot slipped, and brought me down upon my knees. I laid my hand on a broad stone to stay myself; I suppose the snake lay on the other side, who bit my hand in an instant, then slid under the ground, and sounded his rattles. But I soon found him, crushed his head to pieces with a stone, took him up in my left hand, and ran home, sucking the wound on my right hand, and spitting out the poison. This kept it easy: but my tongue and my lips grew stiff and numb, as if they were froze. When I came home, one presently ripped a fowl open, and bound it upon my hand. This eased me a little. I kept my elbow bent and my fingers up, which kept the poison from my arms. Another bruised some turmeric, and bound it round my arm, to keep the poison in my hand. This kept my arm easy for some hours; and my hand, though numb, was not much swelled, nor even painful: but about midnight it puffed up on a sudden, and grew furious, till I slit my fingers with a razor. I also slit the back of my hand, and cupped it, and drew out a quart of slimy stuff; yet my arm swelled. Then I got it tied so fast, that it was almost void of feeling. Yet would it work, writhe, jump, and twine like a snake, change colours, and be spotted. And the spots moved to and fro upon the arm, which grew painful at the bone. All things were applied for two days which could be thought on; but

ate it up bit by bit as one would a carrot or stock of celery, without any seeming repugnance.

The poison of different reptiles produces different effects, and operates in different ways. The bite of the cape hair serpent occasions immediate death unless an antidote be instantly applied. The bite of the dipsas, or as some call it the thirst serpent, occasions intolerable thirst. A man was bitten in the calf of the leg by the dipsas, after tying his garter very tight above his knee to prevent the poison from working upwards, he repaired to the nearest house, which happened to belong to a smith, who immediately laid open the leg, and a great quantity of a watery yellowish humour was discharged, a pretty large plaister was prepared, and tied over the incision, and the patient was advised to abstain from drink a quarter of an hour: he did so; at the end of which time his thirst which had been intolerable, began considerably to abate: the plaister drew away abundance of the contaminated humour, and being frequently cleansed and renewed, the swelling gradually abated, the patient grew easy, and was soon perfectly cured.

The Indians use sorrel and plantain leaves, bruised together, and applied to the wound, which being frequently repeated, draws out the poison, and absterges the wound in the most effectual manner.

without effect, till the ashes of white ash-bark, made into a plaister with vinegar, drew out the poison. We then untied the arm; but within two hours all my right side turned black. Yet it did not swell, nor pain me. I bled at the mouth soon after, and continued bleeding and feverish four days. The pain raged in my arm, and I was by times delirious for an hour or two. After nine days the fever went; but my hand and arm were spotted like a snake all the summer. In autumn my arm swelled, gathered, and burst, so away went poison, spots and all.

"But the most surprising circumstance was my dreams. In all sickness before, these were always pleasant. But now all were horrid. Often I was rolling among old logs; sometimes I was a white oak cut in pieces. Frequently my feet would be growing into two hickory trees: so that it was a terror to me, to think of going to sleep."

5. There is a wonderful provision made for those snakes, who are inhabitants of the waters. A WATER-SNAKE has no air-bladder like fishes: but to make amends for this want, it has a large membranous air-bag on its back, which it empties or fills with air at pleasure, by an aperture which it can shut so close, that the least globule of water cannot enter. By this means it can enlarge or lessen the bulk of its body, and inhabit any depth of water.

As for the SERPENT OF THE WATERS, of which an account is gravely given, by the writer of the Natural History of Norway, which he talks of, as being five or six hundred yards long, and as rearing his head higher than the main mast of a man of war, I presume, it is very nearly related to the CRAKEL of the same author; a sea-monster, to which a whale is but a shrimp, larger than twenty men of war put together. And this our writers of magazines and reviews, swallow without any difficulty!

The king of all reptiles, which are known with any certainty, is the CROCODILE. There are sixty-two joints in the back bone, which, though very closely united, have sufficient play to enable the animal to bend like a bow to the right and the left: so that what we hear of escaping the creature, by turning out of the right line, and of the animal's not being able to wheel after its prey, seems to be fabulous. It is likely the crocodile can turn with great ease; for the joints of its back are not stiffer than those of other animals: and we know by experience, it can wheel about very nimbly for its size.

It is probable, that the smell of musk, which all these animals exhale, may render them agreeable to the savages of some parts of Africa. They are often known to take the part of this animal, which contains the musk, and wear it as a perfume about their persons.—Travellers are not agreed in what part of the body their musk-bags

are contained: some say in the ears; some, in the parts of generation; but the most probable opinion is, that this musky substance is amassed in glands under the legs and arms.

The American crocodile, or alligator, is only fifteen or sixteen feet long. But those bred in Africa, or the East Indies, are said to be between five-and twenty and thirty. It may well be said of him, which cannot be said of the whale, that his scales are his pride: for on his back, as well as on his head, they are impenetrable as steel. No creature dares withstand him. "He is the king of the children of pride." And as every female crocodile lays some hundreds of eggs at once, they would utterly dispeople the waters, were it not that the male devours all he can find of them. And so diligent is he in his search, that scarce one out of a hundred escapes him. It is another instance of divine mercy, that he cannot bite under water. By this circumstance, creatures that are able to dive, generally escape his ravenous jaws. It is a vulgar error, that he moves the upper jaw: he moves the lower only.

The CAMELEON, as well as the alligator, is of the lizard-kind.—Some in Egypt are twelve inches long; but the Arabian seldom exceeds six. He has four feet, and a long flat tail, whereby he hangs on trees, as well as by his feet. His snout is long, his back sharp, and grained like shagreen. He has no ears, neither does he make or receive any sound. The tongue is half the length of the animal, round to the tip, which is flat and hollow, somewhat like an elephant's trunk. And this he darts out, and draws back with surprising swiftness. The great use of this is, to catch flies, which are its proper food; not the air, as is vulgarly thought, by darting it out upon them. Its colour is not always the same. One at Paris, when it was in the shade, and at rest, was of a bluish grey. In the sunshine, this changed to a darker grey, and its less illumined parts to various colours. When handled or stirred it appeared speckled with dark spots bordering upon green. If it was wrapt up a few minutes in a linen cloth, it was sometimes taken out whitish. But it did not take the colour of any other cloth or substance that enclosed it. So that its assuming all the colours it comes near, is a groundless imagination.

The cameleon at London was of several colours, like a mottled coat. The most discernable were, a green, a sandy yellow, and a liver colour. When stirred or warmed it was suddenly full of black spots, as big as a large pin's head. But when it was quiet they gradually disappeared.

There are four species of cameleons: 1. The Arabian, about the size of the green lizard. This is of a whitish colour, variegated with reddish and yellowish spots. 2. The Egyptian, which is of a

middle hue, between a whitish and a faint green. 3. The Mexican. And, 4. A kind which has been frequently shewn in Europe, and differs from all the rest. His head is large: but he alters his body at pleasure, inflating it more or less: and not only his body, but his legs and tail. This is peculiar to him. The body, thus puffed up, will remain so two hours. But it is insensibly sinking all the time. It can continue a long time in either of these states: but is generally uninflated. It then looks miserably lank and lean: its back bone may be seen perfectly, its ribs counted, and even the tendons of the feet distinctly seen through the skin.

Its mouth is furnished with continued, denticulated bones: but it does not appear what use they are of, since it preys on flies, and swallows them whole, unless for holding a stick in its mouth cross-ways: which, according to Ælian, he frequently does, to prevent being swallowed by serpents.

The structure and motion of his eyes are surprising. They appear to be large spheres of which one half stands out of the head, and is covered with a thick skin, perforated with a small hole at top.—Through this is seen a very vivid and bright pupil, surrounded with a yellow iris. This hole is a longitudinal slit, which he opens more or less at pleasure. The motion of his eyes is not less singular. It can turn them, so as to see either forward, backward, or on either side, without moving the head at all, which is fixt to the shoulders. And he can give one eye all these motions, while the other is perfectly still. Each foot has five toes, all of one size, two behind and three before. He moves very slowly on the ground, but on trees more easily. Its tail is then its safety, as it twists it round the branches, when in any danger of falling.

But how can so slow a creature catch the most nimble sorts of insects? What nature has denied it in agility, is abundantly supplied by other means. Its slow and easy motion renders it but little suspected at a distance. And when it comes within a proper space of its object, it stretches out its tail, poises its body, and fixes itself, so as seldom to meet with a disappointment. When all is ready, it uncoils its long, slender tongue, and darts it so swift as scarce ever to miss its prey.

The common colour of the cameleons in Smyrna is green, toward the belly inclining to a yellow. But those in the ruins of the castle are greyish, like the stones among which they breed. One of them, having been kept in a napkin, appeared whitish: but it never changed to red or blue, though wrapt in cloth of those colours for several hours together. On being handled or disturbed, it became stained with dark spots, bordering on green. Sometimes from a green all over, it became full of black spots: sometimes when it appeared black, green spots suddenly appeared. So far is it from being true,

that it changed its colour, according to every object near it. Nor could we perceive this change to be any fixed law; it rather seemed spontaneous. This only was constant; being placed on green, it became green; being on the earth, it changed to the colour of earth.

Another uncommon creature of the lizard kind is a SALAMANDER. This is supposed to live in fire; but without any ground. It is indeed generally found in the chinks of glass-houses, or near furnaces, where the heat is so great, that no other animal could endure it, without being destroyed in a few minutes. But some years ago, the trial was made by several gentlemen, whether it could really live in fire. Some charcoal was kindled, and the animal laid upon the burning coals. Immediately it emitted a blackish liquor, which entirely quenched them. They lighted more coals, and laid it upon them.—It quenched them a second time in the same manner. But being presently laid on a fire, it was in a short time burnt to ashes.

In many parts of Lower Egypt, there is a kind of lizard termed OOCARAL. It resembles a crocodile, only that it is but three or four feet long, and lives wholly on the land. As it is exceedingly fond of the milk of ewes and she goats, it makes use of a remarkable expedient. It twists its long tail round the leg of the ewe or goat, and so sucks her at his leisure.

In most parts of Italy there are swarms of lizards, especially of the green kind. In the spring, hundreds of them are seen, basking on the roofs, and crawling up and down the walls of houses. They are very nimble, and have a bright sleek skin, and beautiful eyes, but are entirely harmless. The scorpions are not so; they harbour not only in old walls and under stones, but in every part of the house, especially the beds; and if touched immediately sting. The sting of an Apulian scorpion, has the same effect with the bite of a tarantula. And it requires the same method of cure; only by different instruments, the flute and bagpipe in particular, with the brisk beat of a drum. But the common remedy against the sting of a scorpion is, to bruise the animal, and bind it on the wound.

6. With regard to water lizards, commonly called NEWTS, which most people suppose to be venomous, they are harmless as land lizards, and are found in summer in most shallow, standing waters. One, who kept several of them in glass jars for many months, observes, in respect of that odd circumstance, casting their skins, they do this every fortnight or three weeks. A day or two before the change, the animal appears more sluggish than usual, and takes no notice of its food, which at other times it devours greedily. The skin in some parts appears loose, and not of so lively a colour as before. It begins this work, by loosening with its fore feet, the skin about its jaws, pushing it forward gently and gradually both above

and below the head, till it can slip out first one leg and then the other. Then it thrusts the skin backward as far as those legs can reach.—Next it rubs itself against pebbles, gravel or whatever else it can meet with, till more than half the body is freed from the skin: which then appears doubled back, covering the hinder part of the body and tail. Then turning its head round to meet its tail, it takes hold of the skin with its mouth, and setting his feet thereon, by degrees pulls it off, drawing the hind legs out, as it did the fore legs. If you then examine the skin, it will be found inside outward, but without the least hole or breach, the part which covered the hind legs seemingly like gloves turned inside out, though entirely perfect and unbroken. They do not however put off the coverings of their eyes, as most kinds of snakes do: for the skin of the newt has always two holes, at the places where the eyes have been. When the skin is off, if it be not soon taken away, the creature swallows it whole.

Many creatures, of very different kinds, put off their skins or shells at certain periods, and if we may guess at other shell fish by the fresh water shrimps, their shells are put off without any breach but one, lengthways in the middle of the belly part, through which the body, tail and claws are pulled out, and the shell left in a manner whole. In the insect tribe, the changes of caterpillars are well known. The spider throws off its skin as frequently, getting out of it by a rupture underneath, and leaving every claw entire; and even the horny covering of his forceps. Even the mite casts its skin at several short periods, and nearly in the same manner.

A particular species of water lizards, abbe Spallanzani terms an AQUATIC SALAMANDER. Yet, he observes, this cannot bear any great degree either of heat or cold. But the most remarkable circumstance relating to it, is, that let its tail, legs or even jaws be cut away, and in a short time they are reproduced. The tail, beside a complete apparatus of nerves, muscles, glands, arteries and veins, has vertebræ of real bone. Their legs do not differ from those of the most perfect animals, in the number of bones, whereof they are composed.

7. Now when the legs and tails of this animal are taken away, new vertebræ, new bones are produced; a phenomenon as wonderful as any hitherto known. This takes place in every known species of salamanders, at any period of their life, on the earth or in the water; and let the length of the divided parts be greater or less. Nor do the constituent parts of the new tail differ from those of the part that was cut, either in number, structure or connection. But a whole year is scarce sufficient to render the new part equal to that which was cut off. Indeed the regenerating power ceases during the winter half year.

When the part reproduced is cut off, it is succeeded by another,

which proceeds in the same manner as the former, and this a second, a third or fourth time: the salamander still forming new parts by the same unalterable laws.

There are in the legs of a salamander ninety and nine bones. In the four regenerated legs there is the same number. The form and internal structure of the reproduced bones, and of the natural, are the same. But the colour of the new bones is somewhat different, and their substance more tender. And all these parts are reproduced in the same manner and at the same time, whether the creature is fed, or kept fasting.

When their jaws are cut off, the same thing happens. New bones are reproduced, new teeth, new cartilages, veins and arteries. From the wonderful reproduction of so many parts in this, may we not extend our inquiry to other animals of equally complicated structure? Let us inquire first concerning tadpoles. If the whole of their tails be cut off, they sink to the bottom of the water and perish. But if part only, they soon recover it. In one summer's day the reproduction makes a rapid progress in young tadpoles. And in a short time, the new part of the tail and the old together, equal the tail of others born at the same time. A second, third and fourth reproduction constantly follows, upon a second, third or fourth section. Nay, successive regenerations never fail, as long as the tadpole keeps its tail.

If no nourishment is given to tadpoles they do not grow, nor are the membranes of the infant state cast off. Yet the tails cut off, will be reproduced nearly in the same time.

If the head of an earth-worm be cut off, a new head is reproduced. Nay, if both the head and tail are cut off from the middle part, both of them are reproduced. Nor is this regenerating power soon exhausted. A second reproduction being cut off, is succeeded by a third, this by a fourth, that by a fifth, and so on.

The same thing takes place in another kind of worm, little known, which the abbe calls an AQUATIC BOAT-WORM. It is composed of rings like the earth-worm, which it shortens or lengthens at pleasure, and so moves from place to place. Toward the head it is as large as the largest goose-quill, and its length is about a span. It lives in shallow, clear water, either stagnated or flowing gently, fixing its fore part in the mud, whence it is nourished. The back part reaches the top of the water, and being stretched and hollowed, forms a kind of boat on the surface. Its sides rise above the water, so that none gets in. But on the least agitation of the water, the insect immediately shuts up his boat, and retires into the mud. When the motion is over, he again thrusts his tail out of the water, and makes his boat afresh, which remains entire till he is disturbed again. And this he does not fail to make, though the mud is removed, and he left with little water.

It seems the organs of respiration are placed in this part, as they are in various sorts of aquatic animals.

These worms are quicker in their reproduction than earth-worms. They more easily recover their heads, as well as tails, and this power exerts itself throughout the whole year.

The case of the snail may seem still more strange. It can first reproduce its horns. After they have been cut off, the trunk becomes like a small knob, whence springs a black point, which is the eye. The trunk then increases in length and size, till it equals the former horn.

If the head be cut off, a new one succeeds; but in a singular manner. If a worm's head be cut off, the reproduction is an entire organic body; that is, a part in miniature exactly similar to that which was cut off. But what appears on the trunk of a snail, is not an entire organic body, containing in miniature all the parts of the head which were cut off; but these parts grow piece by piece at different intervals, and require time to unite and consolidate into one mass, resembling the original pattern. For instance: sometimes the reproduction is like a round, small body, containing the primary parts of the two lips, and of the small horns, which are united to the mouth, and to the new-formed teeth. This round body is placed on the centre of the trunk. The large horns and the fore part of the snail, which in the entire animal are contiguous to the head, are wanting. Another trunk shews the larger horn on the right side, more than a tenth of an inch long, already provided with its eye. Under this, at some distance, the first lineaments of the lip appear. In a third snail arise three horns, two of which are of their natural length, while the third is but just above the skin. Some shew nothing but the trunk, without any sign of reproduction, although the head was taken off at the same time with that of the others, from which are come forth such a number and variety of organs: on the contrary, in some snails, there is no difference between the old and the new head; only there is an ash-coloured line, pointing out exactly where the head was cut off.

That earth-worms feed upon earth, will be put beyond dispute, if any one is at the pains to examine the little curled heaps of dung, which are ejected out of their holes. But it is in all probability, not pure earth, but such as is made of leaves, roots, and plants, when gradually rotted and mouldered away. And what makes this the more probable, is that they are observed to drag the leaves of trees into their holes.

8. Both the whole TAPE-WORM, and every part of it, seems to be a complete animal. In every joint there is a mouth for receiving food, and doubtless organs for digesting it. Single joints, as well as

larger pieces, are frequently voided alive. All those pieces are almost equally turgid with chyle. Now it is not probable, that a single worm should, in voiding, be broke in so many pieces: and had it been done some time before, they would be emaciated. There seems then to be an analogy, between this jointed worm and knotted grass; each joint of which is a complete plant, and propagates itself. It is indeed a zoophyton, a plant-animal, bred in animal bodies: since so large and frequent detruncations do not destroy the life of it.

9. Not only vegetables and animals have their respective insects, to which they afford food and habitation, but stones themselves. Those kind of worms, called, LITHOPHAGI, are a proof of this. One might think it incredible, that these little creatures should subsist by gnawing stones. And yet nothing is more certain, these worm-eaten stones being found almost every where. These are generally lime-stones. Grit and free-stone are seldom eaten in this manner. Yet there is an ancient wall of free-stone in the Benedictine abbey at Caen in Normandy, so eaten with worms, that one may put one's hand into many of the cavities. The worms are covered with a greenish shell, having flat heads, a wide mouth, and four black jaws. And they lay their eggs in those cavities, which they gnaw in the stone.

One more reptile we may examine a little more minutely, in which the wisdom of God is not a little displayed. It is a common LEECH.—When this is at rest, its upper lip forms a regular semicircle. When he moves, this semicircle becomes two oblique lines, the junction of which makes an angle, which he applies to whatever he would fix himself to. The two lips then make a sort of hollow. Both these and its mouth are made of so supple fibres, that they take the figure of the part they are applied to, and fix perfectly close to it.

The wounds it makes are not punctures, but three cuts made like three rays, which uniting in a centre make equal angles with each other. They appear as if made by a fine lancet. They are indeed made by three rows of fine and sharp teeth, which the microscope shews to be placed along the middle of a strong muscle. When the mouth has seized on any part, the muscle exerts its action, and strikes in all the teeth at once.

Between the mouth and the stomach there is a small space, in which are two different arrangements of fibres. The one are set flat and plain, the others are circular. The former contracting in length, enlarge the capacity of the throat; and the circular one determine the blood toward the stomach, by contracting it when the blood is received. Hence it passes into a kind of membranous sack, which serves the animal both for stomach and intestines. This takes up the greatest part of its body. On each side of this long canal there is a number of little bags. These, being filled with blood, swell out the body of

the animal to a large size. Here it remains for many months, and serves the creature for nourishment. If any thing is excreted, it can be only by insensible perspiration, since the creature has no anus, nor any aperture which can supply the place of one.

Frogs change their skins every eight days. Toads, as well as frogs, are harmless, defenceless creatures, and their greatest crime is their ugliness.

Newly generated frogs, which fall to the bottom, remain there the whole day: but having lengthened themselves a little, for at first they are doubled up, they mount to the mucus which they had quitted, and feed upon it with great vivacity. The next day they acquire their tadpole form. In three days more they have little fringes, that serve as fins beneath the head, and these, four days after, assume a more perfect form. It is then they feed greedily upon the pond-weed; and leaving their former food, on this they continue to subsist, till they arrive at maturity. When they come to be ninety-two days old, two small feet begin to sprout near the tail; and the head appears to be separate from the body. The next day the legs are considerably enlarged; four days after they refuse all vegetable food; their mouth appears furnished with teeth; and their hinder legs are completely formed. In two days more the arms are completely produced, and now the frog is every way perfect, except that it still continues to carry the tail. In this odd situation the animal, resembling at once both a frog and a lizard, is seen frequently rising to the surface, not to take food, but to breathe. In this state it continues for six or eight hours, and then the tail dropping off, the animal appears in its perfect form.*

* It is a generally adopted opinion, that the frog is a subject of metamorphosis, and that it exists alternately in the state of fish, and frog. However this may be with regard to a particular species, for there are undoubtedly a variety of species, yet it is pretty certain that it is not universally the case with all the varieties. I have seen the young frogs issuing forth from the spawn so small, I could scarce perceive them with the naked eye; but they were the complete frog, in all its parts, exhibiting all the peculiar instinct, hopping, and performing all the manœuvres common to the species. I have seen them rained from the clouds by millions, and cover the earth to a great extent, so that it was almost impossible to set the foot down, without crushing hundreds of them to death. This did not appear like a metamorphosis from the tadpole state. An ordinary tadpole would make a thousand of them. It rather appears that the clouds passing over the pond, or river when the spawn had been plentifully deposited, and at that season when it was nearly matured, drew it up in the volume of its suction, frittered the egg, and liberated the animal, in which state it was discharged from the cloud in the falling shower. Frogs may be divided into two general classes, the land and the water-kind; the first of which are ejected perfect frogs immediately from the spawn; and the last proceed through the process of metamorphoses, from the tadpole state. The latter appear to be a larger species, and to

Thus the frog, in less than a day, having changed its figure, changes its appetites also. So extraordinary is this transformation, that the food it fed upon so greedily but a few days before, is now utterly rejected. It would even starve, if supplied with no other. As soon as the animal acquires its perfect state it becomes carnivorous, and lives entirely upon worms and insects. But as the water cannot supply these, it is obliged to quit its native element, and seek for food upon land, where it lives by hunting worms, and taking insects by surprise.

"Concerning the toad," says Mr. Arocott, "that lived with us so many years, and was so great a favourite, the greatest curiosity was its being so remarkably tame; it had frequented some steps before our hall door, some years before my acquaintance commenced with it, and had been admired by my father for its size (being the largest I ever met with,) who constantly paid it a visit every evening. I knew it myself above thirty years: and by constantly feeding it, brought it to be so tame that it always came to the candle and looked up, as if expecting to be taken up and brought upon the table, where I always fed it with insects of all sorts. It would follow them, and when within a proper distance, would fix its eyes, and remain motionless for near a quarter of a minute, as if preparing for the stroke, which was an instantaneous throwing its tongue at a great distance upon the insect, which stuck to the tip, by a glutinous matter. The motion is quicker than the eye can follow. I cannot say how long my father had been acquainted with the toad before I knew it; but when I was first acquainted with it, he used to mention it as the old toad. I have known it for thirty-six years. This toad made its appearance as soon as the warm weather came, and retired to some dry bank to repose till spring. When we new-laid the steps, I had two holes made in the third step, on each side, with an hollow of more than a yard long; in which I imagined it slept, as it came from thence at its first appearance. It was seldom provoked. Neither that toad, nor the multitudes I have seen tormented with great cruelty, ever shewed the least desire of revenge. In the heat of the day toads come to the mouth of their hole; I believe for air. I once, from my parlour window, observed a large toad I had in the bank of a bowling-green, about 12 at noon, in a very hot day, very busy and active upon the grass. So uncommon an appearance made me go out to see what it was; when I found an innumerable swarm of winged ants had dropped round his

confine themselves to the water, and its vicinity, whereas the former are to be met with promiscuously in every situation, which nevertheless appear to deposit their spawn in the water, but which having done, they travel in all directions over the country in search of food, themselves becoming food to a numerous tribe of creatures.

hole, which temptation was irresistible. Had it not been for a tame raven, I make no doubt but it would have been now living. This bird one day seeing it at the mouth of its hole, pulled it out, and although I rescued it, pulled out one eye, and hurt it so, that notwithstanding it lived a twelvemonth, it never enjoyed itself, and had a difficulty of taking its food, missing its mark for want of its eye."

All toads are torpid and unvenomous, and seek the darkest retreats, not from the malignity of their nature, but the multitude of their enemies.

CHAPTER V.

OF INSECTS.

THERE remains only the lowest order of animals, usually termed INSECTS, because they have an incision, as it were, which in a manner cuts them in two parts. Of these I would speak the more largely, because generally they are little known.

Rather they are despised, and purposely passed over, as unworthy of our consideration. And yet it is certain, the wisdom of the great Creator does most conspicuously shine in them.

1. As to the shape of their bodies, though it be somewhat different from that of birds, being for the most part not so sharp before, to cut and make way through the air, yet it is better adapted to their manner of life. For, considering they have little need of long flights, and that the strength and activity of their wings, far surpass the resistance they meet with from the air, there was no occasion for their bodies to be so sharpened. But the nature of their food, the manner of gathering it, and the great necessity they have of accurate vision, and large eyes in order thereto, required the largeness of the head, and its amplitude before the rest of the body is all well made, and nicely poised for their flight and other occasions.

The make of their bodies is no less admirable: not built throughout with bones, covered over with flesh, and then with skin, as in most other animals: but clothed with a curious mail of a middle nature, serving both as a skin and bone too; as it were on purpose to shew, that the great Contriver of nature is not bound up to one way only.

How admirably are the legs and wings fitted for their intended service? Not to overload the body nor to retard it, but give it the most proper and convenient motion. What, for example, can be better contrived for this service than the wings? Distended and strength-

oned by the finest bones; and these covered with the finest and lightest membranes; and many of them provided with the finest articulations, and foldings, in order to be laid up in their cases, when they do not use them; and yet always ready to be extended for flight.

2. The structure of the EYE is in all creatures an admirable piece of mechanism. But this is peculiarly observable in that of an insect. Its hardness is an excellent guard against external injuries: and its outer coat is all over beset with curious, transparent inlets, enabling it to see every way, without any loss of time, or trouble to move the eye.

And their feelers, besides their use in cleaning the eyes, are a good guard to them in their walk or flight, enabling them by the sense of feeling to discover annoyances, which, by their nearness, might escape the sight.

The eye of a fly is in truth an assemblage of multitudes, often many thousands of small eyes. Nature has given each fly two large reticular eyes, that are covered with a kind of net-work. And as each contains such a multitude of smaller eyes, one would imagine this might suffice. Yet some flies have four reticular eyes; the two smaller are placed as usual, the two larger are behind the other, on the upper part of the head.

In different species the reticular eyes are of different colours.—Some are brown, some yellow, green, red, and this in all the different shades of those colours. And some have the gloss of metals highly polished.

But, besides these, many species of flies have a sort of eyes, which are not reticular, but of a perfectly smooth and even surface, and far smaller than the reticular. Three of these are on the back of the head of vast numbers, which are triangularly placed. Some have more, and some have less than three. Gnats have none of them. Their heads are in a manner covered with their reticular eyes, so as to leave no room or occasion for smooth ones.

Nor are these smooth eyes peculiar to flies. Other insects also have them: the grasshopper in particular has two, which are placed near the nose.

3. The species of insects are almost innumerable. All of these, some suppose to have no heart, as they have no sensible heat, none that can be perceived either by the touch, or by any other experiment. But this is a mistake. Many indeed have not such a heart as other animals have: but all have something analogous to it, something that answers the same purpose.

Some likewise have thought, that insects have no respiration. But later experiments shew, that there is no species of them which have not lungs, and these larger in proportion than other animals. In

most of them they lie on or near the surface of the body. And hence it is, that if flies are besmeared with oil, or any other unctuous matter, they die in a short time, their respiration being stopt, so that they are properly suffocated.

4. Some also imagined, that insects were generated out of mere putrifaction, because they observed worms come out of putrified flesh, which afterwards turned to flies. But it is certain, if putrifying flesh be shut up close, no worms are ever generated from it. Hence we learn, that flies lay their eggs in flesh, which hatch when it putrifies: so that the animal just comes to life when its food is ready for it. All insects lay their eggs, where there is heat enough to hatch them, and proper food as soon as they are hatched. Those whose food is in the water, lay their eggs in the water: those to whom flesh is a proper food, in flesh: those to whom the fruits or leaves of vegetables are food, are deposited on the proper fruits or leaves. And constantly the same kind is found on the same fruit or plant. Those that require more warmth, are lodged by the parent, in or near the body of some animal. And as for those to whom none of these methods are proper, the parents make their nests by perforations in the earth, in wood, in combs: carrying in and sealing up provisions, that serve both to produce the young, and to feed them when produced.

The eggs of all insects become worms, commonly called nymphæ. They are next changed into aurelia, so called, enclosed in a case; and these dying, a fly or butterfly succeeds.

Some aurelia shine like polished gold. From the beautiful and resplendent colour, some authors have called it a chrysalis, implying a creature made of gold. This brilliant hue, which does not fall short of the best gilding, is formed in the same manner in which we see leather obtain a gold colour; though none of that metal ever enters into the tincture. It is only formed by a brown varnish laid upon a white ground; and the light thus gleaming through the transparency of the brown, gives a charming golden yellow. These two colours are found one over the other in the aurelia, and the whole appears gilded, without any real gilding.

To trace these wonderful changes a little, in one kind of insects. A SILK-WORM, from a small egg, becomes a worm of the caterpillar kind, and feeds on mulberry leaves, till it comes to maturity. Then it winds itself up into a silken case, about the size and shape of a pigeon's egg, and is metamorphosed into an aurelia, in which state it has no motion or sign of life: till at length it awakes, breaks through its silken sepulchre, and appears a butterfly.

As soon as the silk worm has strength, he makes his web, a slight tissue, which is the ground of this admirable work. This is his first

day's employ. On the second, he covers himself almost over with silk. The third, he is quite hid. The following days he employs in thickening his ball, always working from one single end so fine a thread, that those who have examined it, affirm it would reach six miles.

The SILK-SPIDER makes a thread, every whit as strong, glossy, and beautiful as the silk-worm. It spins from seven nipples. These, as so many wire-drawing irons, draw out a viscous liquor, which gradually dries in the air and becomes silk.*

Each of these nipples contain many smaller nipples, invisible to the naked eye; through the several perforations, whereof, numberless finer threads are drawn. Before the spiders begin to spin, they apply more or fewer of the large nipples to the body whence the web is begun. And as they apply them more or less strongly, more or fewer of the smaller nipples come to touch: and accordingly the whole thread will be compounded of more or fewer single threads. One compound thread frequently consists of fifteen or sixteen single ones.

Their threads are of two kinds: one serves only for the web with which they catch flies. The other is much thicker and stronger, in which they wrap up their eggs, in order to shelter them from the cold, as well as from devouring insects. These threads they wind loosely round, resembling the balls of silk-worms that have been loosened for the distaff.

The balls are gray at first, but turn blackish when long exposed to the air. From these balls a silk is made, nothing inferior to the common silk. It takes all kinds of dyes, and may be made into all kinds of stuffs. Only there is a difficulty in keeping the spiders: for they are so extremely quarrelsome, that if a hundred of them be put together, in a few hours scarce twenty will be alive.

5. Amazing wisdom is displayed in the make of the common spider. She has six teats, each furnished with innumerable holes. The tip of each teat is divided into numberless little prominences, which serve to keep the threads apart at the first exit, till they are hardened by the air. In every teat, threads may come out at above a thousand holes. But they are formed at a considerable distance, each of them having a little sheath, in which it is brought to the hole. In the belly are two little soft bodies, which are the first source of the silk. In shape and transparency they resemble glass beads, and the tip of each goes winding toward the teat. From the root of each bead proceeds another branch much thicker, which also winds towards the

* All boneless insects are hermaphrodites, as are snails, leeches, and many sorts of worms. But such worms as become flies are not, being indeed of no sex

same part. In these beads and their branches is contained the matter of which the silk is formed, the body of the bead being a kind of reservoir; the two branching canals proceeding from it.

It was before observed, that the tip of each teat may give passage to above a thousand threads. And yet the size of the teat in the largest spider does not exceed a small pin's head. But the smallest spiders no sooner quit their eggs than they begin to spin. Indeed their threads can scarce be perceived, but the web formed thereof is as thick and close as any. And no wonder, as four or five hundred little spiders often concur in the same work. How minute are their teats! When perhaps the whole spider is less than the teat of its parent. Each parent lays four or five hundred eggs, all wrapt up in a bag. And as soon as the young ones have broken through the bag, they begin to spin.

And even this is not the utmost which nature does. There are some kinds of spiders so small, as not to be discerned without a microscope. And yet there are webs found under them! What must be the fineness of these threads! To one of these the finest hair is as a cart rope.

There are several species of spiders that fly, and that to a surprising height. "The last October," says an eminent writer, "I took notice that the air was very full of webs. I forthwith mounted to the top of the highest steeple on the minster (in York) and could thence discern them yet exceedingly high above me. Some of the spiders that fell upon the pinnacles I took, and found them to be of a kind, which seldom or never enter houses, and cannot be supposed to have taken their flight from the steeple."

There are divers animals as well as spiders, that have some way of conveyance, utterly unknown to us. Thus the animals on the standing waters, so numerous as often to discolour them, and tinge them red, yellow, or green. That these have some way of conveyance is certain, because not only most stagnated waters are stocked with them, yea, not only new pits and ponds, but even holes and gutters on the tops of houses, churches, and steeples. That they have not legs for travelling so far, is manifest; it is therefore probable, either that they dart out webs, and can make themselves buoyant and lighter than the air; or that their bodies are naturally lighter than air, and so they can swim from place to place. It is highly probable, that the eggs of such as are oviparous may be light enough to float therein.

To trace this matter farther: every one must have observed threads floating in the air; but few consider what end they serve. They are the works of spiders. Their usual method is, to let down a thread, and then draw it after them. But in the midst of this work they sometimes desist; and turning their tail according to the wind,

emit a thread with as great violence, as a jet of water discharged from a cock. Thus they continue darting it out, which the wind carries forward, till it is many yards long. Soon after, the spider throws herself off from her web, and trusting herself to the air, with this long tail, will ascend swift, and to a great height with it. These lines, which the spiders attach to them, though unobserved, make these air-threads, that waft them along the air, and enable them to prey on many insects, which they could not reach by any other means.

All spiders that spin, young as well as old, cast out their threads, and sail thereby in the air. And the threads themselves shew the use thereof, being usually hung with the fragments of devoured animals.

When the threads are newly spun, they are always single, and are generally seen ascending higher and higher. But when they are seen coming down, they are sometimes composed of three or four, and either without any spider or with several. It is plain this happens from the threads meeting and entangling in the air, which of course brings them down.

It is common to see a spider mount to the topmost branch of a bush, and from thence dart out several threads one after another, trying, as it were, how she likes them. When she has darted one several yards, she will of a sudden draw it up again, and wind it into a link with her fore-feet, but more frequently break it off, and let it go. A spider will sometimes dart out and break off many threads, before is spins one that it will trust to. But at length she spins one to her liking, and commits herself to the air upon it.

The business of feeding is not all the use of these threads; but they evidently sport and entertain themselves by means of them, floating to and fro in the air, and changing their height at pleasure.

These air-threads are not only found in autumn, but even in the depth of winter. The serene days at Christmas bring out many: but they are only short and slender, being the work of young spiders, hatched in autumn, and are thrown out as it seems only in sport.—The thicker ones of autumn are the only ones intended to support the old spiders, when there is plenty of small flies in the air, which make it worth their while to sail among them.

6. The TARANTULA is a kind of spider, chiefly found near the city of Tarentum, in Apulia. It is about the size of an acorn, and has eight eyes and eight feet. Its skin is hairy; from its mouth rise two trunks, a little crooked and exceedingly sharp. Through these it conveys its poison; they seem likewise to be a kind of moveable nostrils, being in continual motion, especially when it is seeking its food. It is found in other parts of Italy, but is dangerous only in Apulia. And

there it does little hurt in the mountains, which are cooler, but chiefly on the plains. Indeed it is not venomous, but in the heat of summer, particularly in the dog days. It is then so enraged as to fly upon any that comes within its reach.

The bite causes a pain, like that of the stinging of a bee. In a few hours the patient feels a numbness, and the part is marked with a strong livid circle, which soon rises into a painful tumour. A little after he falls into a deep sadness, breathes with much difficulty, his pulse grows feeble and his senses dull. At length he looses all sense and motion and dies, unless speedily relieved. An aversion to blue and black, and an affection for white, red and green, are other unaccountable symptoms of its disorder.

There is no remedy but one. While he lies senseless and motionless, a musician plays several tunes. When he hits on the right, the patient immediately begins to make a faint motion. His fingers first move in cadence, then his feet, then his legs, and by degrees his whole body. At length he rises on his feet, and begins to dance, which some will do for six hours without intermission. After this he is put to bed, and when his strength is recruited, is called up by the same tune to a second dance.

This is continued for six or seven days at least, till he is so weak, that he can dance no longer. This is the sign of his being cured; for if the poison acted still, he would dance till he dropt down dead.—When he is thoroughly tired he awakes as out of sleep, without remembering any thing that is past. And sometimes he is totally cured; but if not, he finds a melancholy gloom, shuns men, seeks water, and if not carefully watched, often leaps into a river. In some the disorder returns that time twelvemonth, perhaps for twenty or thirty years. And each time it is removed as at first.

Equally unaccountable are the two relations published some years since, by a physician of undoubted credit. The first is, a gentleman was seized with a violent fever, attended with a delirium. On the third day he begged to hear a little concert in his chamber. It was with great difficulty the physician consented. From the first tune, his face assumed a serene air, his eyes were no longer wild, and the convulsions ceased. He was free from the fever during the concert; but when that was ended, it returned. The remedy was repeated, and both the delirium and fever always ceased during the concerts. In ten days, music wrought an entire cure, and he relapsed no more.

The other case is that of a dancing master, who through fatigue, fell into a violent fever. On the fourth or fifth day he was seized with a lethargy, which after some time changed into a furious delirium. He threatened all that were present, and obstinately refused all the medicines that were offered him. One of them saying, that

perhaps music might a little compose his imagination; a friend of his took up his violin, and began to play on it. The patient started up in his bed, like one agreeably surprised, and shewed by his head (his arms being held) the pleasure he felt. Those who held his arms, finding the effects of the violin, loosened their hold, and let him move them, according to the tunes. In about a quarter of an hour, he fell into a deep sleep. When he awoke he was out of all danger.

We have many other odd accounts of the power of music; and it must not be denied, but that on some particular occasions, musical sounds may have a very powerful effect. I have seen all the horses and cows in a field, where there was above a hundred, gather round a person that was blowing a French horn, and seeming to testify an awkward kind of satisfaction. Dogs are well known to be very sensible of different tones in music; and I have sometimes heard them sustain a very ridiculous part in a concert.

The great old lion which was some years since kept at the infirmary in Edinburgh, while he was roaring with the utmost fierceness, no sooner heard a bag-pipe, than all his fierceness ceased. He laid his ear close to the front of the den, nibbled his nose and his teeth against the end of his pipe, and then rolled upon his back for very glee. I have seen a German flute have the same effect on an old lion and a young tyger in the tower of London.

7. There is found in America a kind of spider more mischievous than even the tarantula, chiefly in the vallies of Neyba, and others within the jurisdiction of Popayon. It is called a COYA. It is much less than a bug, and is of a fiery red colour. It is found in the corners of walls and among the herbage. On squeezing it, if any moisture from it falls on the skin of either man or beast, it immediately penetrates the flesh, and causes large tumours, which are soon followed by death.

The only remedy is, on the first appearance of a swelling, to singe the person all over with a flame of straw, or of the long grass growing on those plains. This the Indians perform with great dexterity, some holding him by the feet, others by the hands.

Travellers here are warned by their Indian guides, if they feel any thing crawl on their neck or face, not even to lift their hand, the coya being so delicate a texture, that it would immediately burst. But let them tell the Indian what they feel, and he comes and blows it away.

The beasts which feed there, are taught by instinct, before they touch the herbage with their lips, to blow on it with all their force, in order to clear it of these pernicious vermin. And when their smell informs them, that a coya's nest is near, they immediately leap and

run to some other part. Yet sometimes a mule after all his care, has taken in a coya with his pasture. In this case after swelling to a frightful degree, it expires upon the spot. Thus does even the irrational creation "groan and travail in pain together," until it shall be "delivered into the glorious liberty of the children of God!"

8. Mention was made of the extreme smallness of some spiders. But how much smaller are those ANIMALCULA, discerned by the microscope? These are in almost all water. Even in that wherein the best glasses can discover no particles of animated matter, after a few grains of pepper, or a small fragment of a plant of almost any kind, has been sometime in it, animals full of life are produced, and so numerous as to equal the fluid itself in quantity.

A small quantity of water taken from any ditch in summer, is found to abound with just such creatures, only larger. Nay any water, set in open vessels in the summer months, will, after a few days, yield multitudes of them.*

* All those animals which are imperceptible to the naked eye, and cannot be discerned but by the help of glasses, are termed animalcula. The microscope may indeed be said to introduce us into a new world, and exhibit to our view a new creation: which without the help of that noble instrument, must have remained for ever unknown to us. To what degrees of minutia organized beings may extend, it is impossible for us to form a conception of, for considering several microscopes of different focal powers, the second will exhibit an infinite variety of animated beings, which the first would not show us: and the third would appear to multiply in square numbers, a still greater variety of living creatures, which we could not obtain even a glimpse of by the second; and so on, in progressive ratios, to the utmost improvement of microscopic powers. This is similar to observations on the fixed stars, by various telescopes: the last improved double reflecting telescope, invented by that celebrated astronomer, Dr. Herschell, discovers myriads, and myriads of fixed stars, which no telescope of previous invention would afford a glimpse of, and could those telescopic powers be improved, myriads of others would no doubt be discovered in the vast expanse of the universe, which that could never reach.

The smallest living creatures discoverable by the microscope, are generally those which inhabit the waters. Infinite varieties of the species called animalcula infusoria, may be generated at pleasure by vegetable and animal infusions. Indeed there is scarce any kind of water, unless impregnated with some mineral substance, but what discovers some living creatures. Mr. Lewenhoeck says that he could not at first discover any living creatures in rain water, but that after standing some days, he could discern innumerable multitudes, many thousands of times less than a grain of sand; and in proportion to a mite, as a bee is to a horse. —In other rain water which had likewise stood some time, he found the smallest sort he had ever seen, and in a few days more, met with others eight times as big as these, and almost round. In another quantity of rain water, that had been exposed like the former, he discovered a species, with two little horns, in continual motion; the space between the horns was flat, the body was roundish, and tapering a little towards the end, where a tail projected four times as long as the body, and of the thickness of a spider's thread. He observed several hundreds of these within the space which a grain of sand would occupy. If they happened to be

These we know by their future changes are the FLY-WORMS of GNATS, and several other sorts of flies. And we easily judge, they owe their origin to the eggs of the parent-fly, there deposited. No doubt then but the air abounds with other animalcula, as minute as the worms in these fluids. And these are the flying-worms of these animalcula, which after a proper time spent in that state, will become flies like those to which they owe their origin.

The waters in which different liquors are infused afford a proper matter for the worms of different species of flies. And some of these doubtless are viviparous, others oviparous. This may occasion the different time taken up for producing insects in different fluids. Those proper for the worms of a viviparous fly, will be soonest full of them: whereas a longer time is required to hatch the eggs of the oviparous.

Now, every animalcule being an organized body, how delicate must the parts be that are necessary to make it such, and to preserve its vital actions? It is hard to conceive how, in so narrow a compass, there is a heart, to be the fountain of life, muscles necessary for its motion, glands to secrete its fluid, stomach and bowels to digest its food, and other innumerable parts, without which an animal cannot subsist. And every one of these must have fibres, membranes, coats,

entangled they would struggle very hard to disengage their tails. He observed a second sort, of an oval figure, with flat bodies, and several feet, moving exceeding quick. A third sort were also observed, twice as long as broad, and eight times smaller than the first, yet in these he discerned little feet, whereby they moved very nimbly. He perceived likewise a fourth sort a thousand times smaller than a louse's eye, which exceeded all the rest in briskness; he found these turning themselves round, as it were upon a point, with the celerity of a top. And he says there were several other sorts.

The production of animalcula infusoria, is very surprising. In four hours time, an infusion of cantharides has produced animalcula even less than any of the former, and which seemed to be of very different natures, and not subject to a like fate with other animals; but by dividing themselves in two, appeared to perpetuate their youth, and enjoy a kind of immortality. Hot mutton gravy, secured in a phial by a cork, and afterwards set upon hot ashes, to destroy as much as possible every principle of life, has nevertheless, after standing a few days, been found swarming with animalcules. An infinite variety of animalcules have been produced by different infusions; as by Hemlock, Pine, Ash, Oak, Beech, Mirtle, &c. And by different animal substances In short it would appear from these wonderful discoveries, and experiments, as if life was universal, and spontaneous, and that the all-wise Creator had so ordained it, that the principle of life should pervade all worlds, and be instant like electricity, to attach itself to all susceptible bodies; and organize matter according to its own specific principles, and according to the degrees of susceptibility of that matter.

But there is evidently a discrimination to be made, between life which is spontaneous, and life which is procreative, or by sexual generation: as there is between instinct, and intellect. Which subject I may have occasion to remark upon hereafter.

veins, arteries, nerves, and an infinite number of tubes, whose smallness exceeds all efforts of imagination. And yet there are parts that must be infinitely smaller than these, namely the fluids that move through them, the blood, lymph and animal spirits, whose subtility, even in large animals, is incredible.

As to some of the animalcules observed by Lewenhoeck, he computed, that three or four hundred of them placed close together in a line, would only equal the diameter of a grain of sand. Twenty-seven millions then of these animals equal in bulk a grain of sand.

But Hartsoeker carries the matter still farther. If, says he, according to our present system of generation, all animals were formed from the beginning of the world, and enclosed one within another, all of them in the first animal of each species: how minute must the animalcula produced now, have been at the beginning!

9. Even the meanest and most contemptible of insects, shews the wisdom of its Creator. Fleas, for instance, deposit their eggs only on such animals, as afford them a proper food. These hatch into worms of a shining pearl-colour, which feed on the scurf of the cuticle. In a fortnight they are very active, and if disturbed, suddenly roll themselves into a ball. Soon after they begin to creep, with a very swift motion. When arrived at their full size, they spin a thread out of their mouth, wherewith they form themselves a case. After a fortnight's rest here, each of them bursts a perfect flea, leaving its exuviæ behind. It is milk-white till the second day before its eruption; then it changes colour and gets strength, so that upon its first delivery, it springs nimbly away.

Minute animals are found proportionably much stronger and more active than large ones. The spring of a flea in its leap vastly exceeds any thing greater animals are capable of. Mr. De Lisle has computed the velocity of a little creature, which ran three inches in a half a second. Now supposing its feet to be the fifteenth part of a line, it must then, in order to travel over such a space in such a time, make five hundred steps in the space of three inches: that is, it must shift its feet five hundred times in a second, or in the ordinary pulsation of an artery. What is the motion of any large animal, in comparison of this? Or what is the swiftness of a greyhound or a race-horse, to that of such an animalcule?

The body of a flea appears, by a microscope, to be all over curiously adorned with a suit of polished sable armour, neatly jointed, and beset with multitudes of sharp pins. It has six legs, the joints of which are so adapted, that it can fold them up one within another; and when it leaps, they all spring out at once, whereby its whole strength is exerted, and the body raised above two hundred times its own diameter.

10. A LOUSE also affords to our observation, a very delicate structure of parts. It is divided into the head, the breast, and the tail. In the head appear two fine black eyes, with a horn that has five joints and is surrounded with hairs, standing before each eye. From the nose projects in a sheath the piercer or sucker, which it thrusts into the skin. This is judged to be seven hundred times finer than a hair. It has no other mouth than this.

The skin of the breast is transparent, and from the under part of it proceed six legs, each having five joints; each leg is terminated by two claws, which it uses as we would a thumb and middle finger.

If one of them, when hungry, be placed on the back of the hand, it will thrust its sucker into the skin, and the blood it sucks may be seen passing in a fine stream to the fore-part of the head. Falling into a roundish cavity there, it passes on to another receptacle in the middle of the head. Thence it runs to the breast, and then to a gut which reaches to the hinder part of the body, where in a curve it turns again a little upward. It then stands still, and seems to undergo a separation; some of it becoming clear and watery, while other black particles pass down to the anus.

Lice are not hermaphrodites; and the males have stings, which the females have not. A female lays in twelve days a hundred eggs, which hatch in six days. Suppose these produce fifty males, and as many females: these females coming to their full growth in eighteen days, may each in twelve days lay a hundred eggs more. And these in six days more may produce a young brood of five thousand. So swiftly do these creatures multiply!

Most animals are subject to lice, but each of a different kind, and none of them like the human. Nay, even insects are not free. Beetles, ear-wigs and snails are particularly subject to them. Numberless little red lice are often seen about the legs of spiders. A sort of whitish lice are common on bees. They are also on ants.

Fishes, one would think, living in the water, and perpetually moving to and fro, should be free from lice. But they have their sorts too, which nest under their scales, the salmon in particular. Besides which, there are frequently found great numbers of long worms, in the stomach and other parts of fish. And these work themselves so deeply into their flesh, that they cannot easily be got out.

Many insects are bred in the nostrils of sheep. One may take out twenty or thirty rough maggots at a time. A rough, whitish maggot is found also within the intestinum rectum of horses. Others are generated in the backs of cows, which at first are only a small knot, being an egg laid there by some insect. Afterwards it grows bigger, and contains a maggot, lying in a purulent matter.

In Persia, slender worms, six or seven yards long, are bred in the legs and other parts of men's bodies. Yea, there have been divers instances of worms taken out of the tongue, gums, nose and other parts, by a person of Leicester, before many witnesses.

11. A very extraordinary kind of insect, is that which is called a DEATH-WATCH, because it makes a noise like the beating of a watch. One is a small beetle, somewhat more than a quarter of an inch long, of a dark brown, and spotted, having a large cap on the head, and two feelers springing from beneath the eyes. Dr. Derham observed it to draw back its mouth, and beat with its forehead. He kept two, a male and a female, in a box, for some months, and could bring one of them to beat when he pleased, by imitating its beating. And he soon found this ticking to be the way, whereby they wooed one another.

The other kind is a greyish insect like a louse, which beats some hours together without intermission, and that slowly; whereas the former beats only seven or eight strokes at a time, and much quicker. It is very common in summer in all parts of our houses, is nimble in running to shelter, and shy of beating, if disturbed; but is free to beat, and to answer your beating, if you do not shake the place where it lies. This commonly, if not always, beats in or near paper. It is at first a small, white egg, like a nit. It hatches in March, and creeps about with its shell on. It is then smaller than the egg itself, but soon grows to the perfect size.

That death-watches sometimes beat, without wooing, we may learn from the account of an accurate observer. "As I was in my study, I happened to hear what is called a death-watch. Inclining my head towards a chair, I found it was beating there. The manner of its beating was this. It lifted up itself on its hinder legs, and extending its neck, struck its face upon the sedge, which was bared upon its outward coat, about the length of half an inch. The impression of its strokes was visible: the outward coat of the sedge being depressed, where it had just been beating, for about the compass of a silver penny. I am inclined to think it beats for food. There were several places on the sedge, where it had been at work, and where it had probably been sojourning for some days.

"Possibly the insect may sometimes woo its mate by beating thus: but it was not the case now. It had not any other of its kind near it. It seemed therefore to be preparing its food. It was about a quarter of an inch long, of a dark, dirty colour, having a broad helmet over its head, which he can draw up under it, so that is a notable defence against the falls, to which he is continually exposed, creeping over rotten and decayed places.

"The second day after I took it, I opened the box, and set it in the sun. It was soon very brisk, and crept nimbly to and fro, till suddenly it struck out its wings, and was going to take its leave; but on my shading it over, it drew in its wings, and was quiet."

This seems to be the smallest of the beetle kind. A gentleman describes one of a very different sort, in the philosophical transactions. "On the removal of a large leaden cistern, I observed at the bottom of it, black beetles. One of the largest I threw into a cup of spirits, (it being the way of killing and preparing insects for my purpose.) In a few minutes it appeared to be quite dead. I then shut it up in a box about an inch and a half diameter, and throwing it into a drawer, thought no more of it for two months, when opening the box, I found it alive and vigorous, though it had no food all the time, nor any more air than it could find in so small a box, whose cover shut very close. A few days before, a friend had sent me three or four cock-roaches.

"These I had put under a large glass; I put my beetle among them, and fed them with green ginger, which they ate greedily; but he would never taste it, for the five weeks they lived there. The cock-roaches would avoid the beetle, and seem frightened at his approach: but he usually stalked along not at all regarding whether they came in his way or not. During the two years and a half that I have kept him, he has neither eat nor drank.

"How then has he been kept alive? Is it by the air? There are particles in this, which supply a growth to some species of plants, as sempervive, orpine and house-leek: may not the same or the like particles supply nourishment to some species of animals? In the amazing plan of nature, the animal, vegetable and mineral kingdoms, are not separated from each other by wide distances, but near their boundaries, differ from each other, by such minute and insensible degrees, that we cannot find out certainly, where the one begins, or the other ends. As the air therefore nourishes some plants, so it may nourish some animals: otherwise a link would seem to be wanting, in the mighty chain of being. It is certain cameleons and snakes can live many months without any visible subsistence: and probably not merely by their slow digestion, but rather by means of particles contained in the air, as this beetle did; yet doubtless in its natural state, it used more substantial food. So the plants abovenamed thrive best with a little earth, although they flourish a long time, and send forth branches and flowers, when they are suspended in the air.

"Even in the exhausted receiver, after it had been there half an hour, it seemed perfectly unconcerned, walking about as briskly as ever. But on the admission of the air, it seemed to be in a surprize for a minute.

"After I had kept him half a year longer, he got away, through the carelessness of a servant who took down the glass."

12. A FEMALE FLY, within four and twenty hours after her congress with the male, begins to deposit her eggs on some substance proper to give nourishment to the worm that is to be produced. These eggs in general are white and oblong. But there are some of them which are singular. To describe one species of them may suffice; the eggs laid on hog's dung.

They are white and oblong, but of a peculiar make. At one end of each of these eggs, between that end and the middle, are two little wings, standing out on either side. As soon as the fly has laid her eggs, she thrusts them into the dung. This keeps the coat of the egg soft; otherwise the embryo could never get out. But if the whole egg were thrust in, the creature would be suffocated, as soon as it is hatched. Therefore part only is to be immersed, and part to be left out. And this is admirably provided for by these wings. For when the female thrusts in the egg, it easily enters at the smaller end, which is the part first protruded from her body; but it stops at the wings, and so the upper part remains open to the air.

Some species of flies fasten their eggs to the sides of vessels of water. All these eggs have a thin flake running down the two sides diametrically opposite. So that they look as if they were enclosed in a frame. The use of this frame is, to hold the body of the egg more firmly to the side of the vessel. Those eggs which have it not, are deposited by the female fly with a viscous matter about them.

Some flies lay their eggs in the bodies of caterpillars. These are at great pains to carry those caterpillars to the places where it is proper their eggs should be hatched. There is one species whose worm can never succeed, unless it be both bred in the caterpillar, and that caterpillar buried under ground. To this purpose the parent, when ready to lay her eggs, forms a hole in the ground, and covers it with a little clod. Then she goes in search of a proper caterpillar, perhaps one much larger than herself, which nevertheless she drags to her hole. This she uncovers, and goes in to see if all is right. Then she goes and draws the caterpillar in, deposits her eggs in his flesh, and stops up the hole with pellets of dirt and dust, carefully rammed in between. When the worms are hatched, they feed on the flesh of the caterpillar till they are full grown; then they change into aurelia, and afterwards into the form of the parent fly, in which state they easily make their way out of the ground.

Some of these lay their eggs in the bodies of smaller flies. They often fly with one of them in their legs, the head of it being close to their bellies. They carry these to little holes in the ground. In

the first they lay their eggs. Then they bring others, to be food for their young when hatched. One fly is not enough; therefore their parents carry them more every day, crawling backward into the hole, and dragging in the flies after them. When the worms change into aurelia, their cases are made of the exuviæ of the flies they have been feeding on.

The eggs of insects are usually the occasion of what are termed blights. These seldom happen but on the blowing of sharp easterly winds. Many insects attend those winds, and lay their eggs on proper plants. Indeed the large worms or caterpillars, which attend some blights, seem to be only hatched by those winds. But they probably bring those swarms of insects, which occasion the curling of the leaves of trees.

Every insect feeds on one plant and no other. On this only it lays its eggs. Hence it is, that one kind of tree only is blighted, and the rest escape. All trees then cannot be blighted at once, unless one wind could bring the eggs of all insects, with as many different degrees of heat and cold, as are required to hatch and preserve each species.

And what though we do not always perceive animals in blights? By microscopes we discover animalcula, a million times less than those that are perceivable by the naked eye. The gentlest air may waft these from place to place: so that it is no wonder if they are brought to us from Great Tartary; even the cold air of which may give them life, and from whence there is not so much sea as to suffocate them in their passage, by the warmth and saltness of its vapours.

Trees are preserved from blights by sprinkling them with tobacco-dust or pepper-dust, which are death to all insects.

But one kind of blight is caused, merely by long continued, dry easterly winds. These stop the perspiration in the tender blossoms, so that in a short time they wither and decay: soon after the tender leaves are affected; their perspiring matter becoming thick and glutinous, so as to be proper nutriment for the insects, which are then always found upon them. In this case the insects are not the cause, but the effect of the blight.

It is a kind of blight that produces galls, which are the buds of oaks swelled out. The cause is, into the heart of the tender bud a fly thrusts one or more eggs. This egg soon becomes a worm, and eats itself a little cell in the pith of the bud, which would have grown into a branch. The sap, which was to nourish that branch, being diverted into the remaining parts of the bud, these grow large and flourishing, and become a covering for the cell of the insect.

Not only the willow and some other trees, but plants also, nettles, ground-ivy, and others, have such cases produced upon their leaves. The parent insect, with its tail, bores the rib of the leaf when tender, and makes way for her egg into the very pith. Probably she lays it there, with some proper juice, to prevent the vegetation of it. From this wound arises a small excrescence, which when the egg is hatched, grows bigger and bigger, as the worm increases, swelling on each side the leaf, between the two membranes. This worm turns afterwards to an aurelia, and then to a small green fly.

The Alleppo-galls, wherewith we make our ink, are of this number, being only cases of insects, which gnawed their way out, through the little holes we see in them.

For a sample of the tender galls, see the balls as round and sometimes as big as small musket bullets, growing under oaken leaves, close to the ribs, of a greenish yellowish colour. Their skin is smooth, with frequent risings therein. Inwardly they are very soft and spongy; and in the very centre, is a case, with a white worm therein, which afterwards becomes a fly. As to this gall, there is one thing peculiar: the fly lies all winter within this ball, and does not come to maturity till the following spring. In the autumn these balls fall to the ground with their leaves. Yet the insect enclosed in them, is fenced against the winter frosts, partly by other leaves lying upon them, and partly by the thick spongy wall, afforded by the galls themselves.

13. There are few insects more prolific than the GNAT. All its changes, from the egg to the perfect animal, are fulfilled in three weeks or a month: and there are usually seven generations of them in a year, in each of which the parent lays two or three hundred eggs. These she ranges in the form of a boat, and each egg is shaped like a nine-pin. The thicker ends of these are placed downward. They are firmly joined together by their middles, and their narrower parts stand upward.

Viewed with a microscope, the larger end is observed to be terminated by a short neck, the end of which is bordered by a kind of ridge. The neck of each is sunk in the water, on which the boat swims: for it is necessary they should keep on the surface, since otherwise the eggs could never be hatched.

The ranging these in so exact order, requires the utmost care of the parent. Gnats lay their eggs in the morning hours, and on such waters as will give support to their young. Here the parent places herself on a small stick, a leaf, or any such matter, near the water edge, in such a manner that the last ring but one of her body touches the surface of the water. The last ring of all, where there is the

passage for the eggs, is turned upward, and every egg is thrust out vertically. When it is almost disengaged, she applies it to the sides of the cluster already formed: to which it readily adheres by means of a viscous matter, wherewith they are covered.

The great difficulty is, to place the first laid eggs in a proper position to receive the rest, and to sustain themselves and them, in a proper direction. These she with great precaution places exactly, by means of her hinder legs. And when a sufficient number of them are arranged, all the rest is easy: inasmuch as these are a firm support to all that follow them.

These are circumstances sufficiently extraordinary in this little animal; but it offers something still more curious in the method of its propagation. However similar insects of the gnat kind are in their appearances, yet they differ widely in the manner in which they are brought forth; for some are oviparous, and some viviparous; some are males, some are females, some are of neither sex, yet still produce young, without any copulation whatsoever. This is one of the strangest discoveries in all natural history! A gnat, separated from the rest of its kind, and enclosed in a glass vessel, with air sufficient to keep it alive, shall produce young, which also, when separated from each other, shall be the parents of a numerous progeny. Thus down for five or six generations do these extraordinary animals propagate in the manner of vegetables, the young bursting from the body of their parents, without any previous impregnation. At the sixth generation, however, their propagation stops; the gnat no longer produces its like from itself, but requires the access of the male.

14. A CICADULA is a small insect found in May and June, on the stalks or leaves of plants, in a kind of froth, commonly called cuckoo spit. This froth is not from the plant, but the mouth of the animal; and if it be gently wiped away, will be presently seen issuing out of its mouth, till there is as large a quantity of it as before. They are of the shape of a louse, some being whitish, some yellowish, and others green. They often change their skins, while they live in this froth, and only creep a little. But when they leave the plant they hop and fly, having wings which cover the whole body.

The COCHINEAL is an insect of the same species with the gall insect. It is found adhering to several plants; but only one communicates its valuable qualities to it, the OPANTIA OF PRICKLE PEAR. This consists of thick leaves, and its fruit, resembling a fig, is full of a crimson juice, to which the insect owes its colour.

When first hatched, it is scarce bigger than a mite, and runs about very swiftly. But it soon loses its activity, and fixing on the least and

most juicy part of the leaf, clings there for life, without moving any more, only for its subsistence, which it sucks in with its proboscis.

The male has no appearance of belonging to the same species.—They are smaller than the female, have wings, and like the butterfly, are continually in motion. They are constantly seen among the females, walking over them, as it were carelessly, and impregnating them. But it is the female only which is gathered for use, four times in the year: for so many are the generations of them.

15. The most singular part of the life of a DRONE-FLY, is that it passes in the form of a worm. It is then distinguished from all other worms by its long tail: at different times this is indeed of different lengths: but it is always longer than the worm itself. It is round, smooth, and very small at the extremity; sometimes no thicker than a horse-hair. To know the use of this tail, we must first know the nature of the worm itself. It is an aquatic, and never leaves the water till it changes into its fly-state. They lie in multitudes in the mud at the bottom of vessels of stinking water. Put them into vessels of clean water, and they will soon shew the use of their tails. Though they live under water, they cannot live without breathing fresh air. This is the end to which their long tails serve. For even while they lie buried in the mud, their tails are extended to the top of the water, and being open at the extremity, let air into their bodies. And as soon as they are in a vessel of fresh water, they get to the bottom and thrust up their tails to the surface. They can lengthen them at pleasure: to be assured of this, you need only pour in more water. The worms then lengthen their tails proportionably, in order to breath from the surface: by adding more and more water you will find they can extend their tails to the length of five inches: an extremely remarkable length for a creature little more than half an inch long. Beyond five inches however they cannot go. And if you make the water a greater depth, they leave the bottom, and either travel up the sides of the vessel to a proper height; or else swim in the water, at the depth of five inches.

16. No species of flies is more remarkable than the larger FIRE-FLY of Jamaica. It is above an inch long, and proportionably broad. Most of its internal parts are luminous; only the thickness of the covers hinders its appearing. But on forcing the rings that cover the body a little asunder, light issues from all the entrails. The head has two spots just behind the eyes, which emit streams of strong light. But though these flow naturally from the insect, yet it has a power of interrupting them at pleasure. And then these spots are as opaque as the surface of the body.

A person may read the smallest print by the light of one of these insects, if held between the fingers, and moved along the line, with

the luminous spots over the letters. They are seldom seen in the day, but wake in the evening, and move and shine most part of the night. They readily fly towards each other. Hence the negroes have learned to hold one between their fingers, and wave it up and down, which others seeing fly direct toward it, and pitch upon the hand. They are so torpid by day, it is hard to make them discover signs of life; and if they do, they presently relapse into the same state of insensibility. As long as they remain awake they emit light: but they are vigorous only in the night.

17. One more insect of the fly-kind, we cannot pass by unnoticed: the EPHEMERON, or fly that lives but part of a day. It appears usually about midsummer. It is produced about six in the evening, and dies about eleven. But before it becomes a fly, it exists three years as a worm in a clay case. It never eats from the time of its change to its death, nor has any organs for receiving or digesting food. The business of its life is summed up in a few words. As soon as it has dropt its clay coat, the poor, little animal, being now light and agile, spends the rest of its short, winged state, in frisking over the waters. During this the female, being impregnated, drops her eggs upon the water. These sink to the bottom, where they are hatched by the heat of the sun into little worms, which make themselves cases in the clay, and feed on the same, or on what the waters afford, without any need of parental care. Thus they are inhabitants of the water, till the time comes for shaking off their shell, and emerging into air.

Of one sort of ephemeron, Mr. Collinson writes thus. "May 26, 1744: I was first shewn this, by the name of MAY-FLY. It lies all the year, but a few days, at the bottom of the river; then rises to the surface of the water, and splitting open its case, up springs the new animal, with a slender body, four shining wings, and three long hairs in its tail. It next flies about to find a proper place, where it may wait for its approaching change. This comes in two or three days. I held one on my finger, while it performed this great work. It was surprising to see, how easily its back split, and produced the new birth, which leaves head, body, wings, legs, and even its three-haired tail behind, or the cases of them. After it has rested a little, it flies nimbly to seek its mate. The males keep under the trees, remote from the river. Hither the females resorted, and when impregnated, soon left the males, sought the rivers, and kept continually plying up and down on the water. Every time they darted down, they ejected a cluster of eggs. They then sprang up again. Thus they went up and down, till they had exhausted their stock of eggs and spent their strength, being so weak that they can rise no more, but fall a prey to the fish. This is the end of the females. The

males never resort to the river, but having done their office, drop down and die.

"In a life of three or four days they eat nothing. They have no apparatus for that purpose; yet they have strength to shed their skin, and to perform the ends of their life with great vivacity."

But how poor an end, to our apprehension, is answered by the life of this, and innumerable other animals!

18. The eggs of BUTTERFLIES do not increase in bulk while in the body of the female. As soon as they are impregnated by the male, they are ready to be laid. But this requires some time, both because of their number, and the nicety with which she arranges them. This indeed is the whole business of her life: for when they are laid, she dies.

The female does not deposit them at random, but searches out a sort of plant which the caterpillars can feed on as soon as they are hatched. Neither does she scatter them irregularly and without order, but disposes them with perfect symmetry, and fastens them together by a viscous liquor discharged from her own entrails. And those species whose hinder part is covered with long hairs, gradually throw them all off, and therewith make a nest, wherein the eggs are kept safely, till the time of their hatching.

19. Some CATERPILLARS are hatched in the spring, as soon as the leaves they are to be fed on begin to bud. After thirteen days, they change into aurelia, and having passed three weeks in that state, they issue forth winged, with all the beauty of their parents.

The wings of butterflies fully distinguish them from flies of every other kind. They are four in number; and though two of them be cut off, the animal can fly with the two remaining. They are in their own subsistence transparent: but owe their opacity to the beautiful dust with which they are covered, and which has been likened, by some, to the feathers of birds: by others, to the scales of fishes. In fact, if we regard the wing of a butterfly with a good microscope, we shall perceive it studded over with a variety of little grains of different dimensions and forms, generally supported on a footstalk, regularly laid upon the whole surface. Nothing can exceed the beautiful and regular arrangement of these little substances. Those of one rank are a little covered by those that follow; they are of many figures; here may be seen a succession of oval studs; there a cluster of studs, each in the form of a heart: in one place they resemble a hand open; and in another, they are long or triangular; while all are interspersed with taller studs that grow between the rest, like mushrooms upon a stalk.

The eyes of butterflies have not all the same form, for in some they are large, in others small. In all of them the outward coat has a

lustre, in which may be discovered the various colours of the rainbow. When examined closely, it will be found to have the appearance of a multiplying glass: having a great number of sides or facets, in the manner of a brilliant cut diamond. These animals, therefore, see not only with great clearness, but view every object multiplied in a surprising manner. Puget adapted the cornea of a fly in such a position, as to see objects through it by means of a microscope: and nothing could exceed the strangeness of its representations; a soldier who was seen through it, appeared like an army of pigmies; for while it multiplied, it also diminished the object.

It still, however, remains a doubt, whether the insect sees objects singly, as with one eye; or whether every facet is itself a complete eye, exhibiting its own object distinct from all the rest. The trunk, which few butterflies are without, is placed exactly between the eyes; which, when the animal is not seeking its nourishment, is rolled up like a curl. A butterfly, when it is feeding, flies round some flower, and settles upon it. The trunk is then uncurled, and thrust out, searching the flower to its very bottom. This search being repeated seven or eight times, the butterfly then passes to another; and continues to hover over those agreeable to its taste, like a bird over its prey. This trunk consists of two hollow tubes, nicely joined like the pipes of an organ.

Butterflies, as well as moths, employ their short lives in a variety of enjoyments. Their whole time is spent either in quest of food, which every flower offers: or in pursuit of the female, whose approach they often perceive at above two miles distance. Their sagacity in this particular is astonishing; but by what sense they are capable of doing this, is not easy to conceive. It cannot be by sight, since such small objects must be utterly imperceptible at half the distance: it can scarcely be by the sense of smelling, since the animal has no organs for that purpose. Whatever be their powers of perception, certain it is, that the male, after having fluttered, as if carelessly about, for some time, is seen to take wing and go forward, sometimes for two miles together, in a direct line to where the female is perched on a flower.

Caterpillars are of no sex, it not being their business to propagate, till they commence butterflies. Yet many of them are not so harmless as they seem; for they destroy their fellows whenever they can. Put twenty caterpillars of the oak together in a box, with a sufficient quantity of leaves, their natural food, yet their numbers will decrease daily, till one only remains alive. The stronger seizes the weaker by the throat, and gives him a mortal wound. When he is dead, the murderer begins to eat him up, and leaves only the skin

with the head and feet. But this is not the case of all. Many species live peaceably and comfortably together.

Yet even these are exposed to dangers of a more terrible kind.—The worms of several sorts of flies, continually prey upon them. Some are upon, some under the skin, and both eat up the poor, defenceless animal, alive.

It is surprising to see with what industry these little creatures weave the cases, in which they pass their aurelia state. Some are made of silk, mixt with their own hair, with pieces of bark, leaves, wood, or paper.

There is one sort that builds in wood, and gives its case a hardness greater than that of the wood itself. This is the caterpillar of the willow, which is one of those that eat their exuviæ. He has sharp teeth, wherewith he cuts the wood into a number of small fragments. These he unites together into a case, by means of a peculiar silk, which is a viscous juice that hardens as it dries. In order to make this silk enter into the very substance of the fragments, he moistens every one of them, by holding them successively in his mouth for a considerable time. In this firm case he is afterward to be included till he becomes a butterfly. But how can a creature of this helpless kind, which has neither legs to dig, nor teeth to gnaw, get out of so firm and strong a lodgment as that wherein it is hatched? Nature has provided for this also. As soon as it is hatched, it discharges a liquor which dissolves the viscous matter that holds the case together, so that the fragments fall in pieces of themselves. And, accordingly, near its mouth, there is always found a bladder of the size of a small pea, full of this liquor.

Some caterpillars spin all the way they walk, a thread of silk which marks their journey. Now what end does this serve? A little observation will shew. Trace one of them till he chances to fall, and you will see the use of this thread. Being fastened to the leaves and twigs, it stops the creature's fall. Nor is this all. It can also, by means of this thread, reascend to the place from whence it fell. And when it is safely got up again, it continues its motion as before.

Another curious artifice is that by which the same species of caterpillars make themselves cases of leaves before they change into aurelia. The nicest hands could not roll these up so regularly, as they do without hands or any thing like them. They perform it thus: the caterpillar places itself on the upper side of the leaf, so far from the edge that he can reach it with his head. Turning himself round, he then brings the edge of the leaf to the point just opposite to it. It next draws lines from the edge of this leaf to that point; and

doing this all the way along the leaf, its narrowness towards the point makes it form a close case there. It strengthens the first bending of the leaf, by many parallel threads, and then fastening other threads to the back part of the leaf, draws them as tight as it can. The case is then formed. The same method repeated makes the additional cases, five or six over each other. And every one of these is sufficiently strong, so as to make the inner ones useless. He then enters his cell, and undergoes his change. Mean time his covering serves him also for food. For so long as he has need to eat, he may feed upon the walls of his castle: all of which may be eaten away except the outer one of all. Probably every caterpillar makes his case thick enough to serve the necessary calls of his future hunger.

Many species of butterflies lay a great number of eggs in the same place. These all hatch very nearly at the same time. And one would naturally suppose, that the young brood of all, would be inclined to continue and live together. But it is not so: the different species have different inclinations. Some keep together from the time they are hatched, till they change into aurelia. Others separate as soon as able to crawl, and hunt their fortune single. And others live in community till a certain time, and then each shifts for itself. Those that live wholly together, begin by forming a line with their little bodies upon a leaf; their heads all standing even, and in this manner they move and eat together. And often there are several ranges of this sort, which make so many phalanxes, and eat into the leaf they stand on, with perfect equality.

Many do this while young, who, when they grow large, make one common habitation, surrounded by a web, which is the joint work of all: within which each has a nest of its own spinning.

When they have made their common lodging, each takes its course over the tree or bush for food. Thus many hundreds of them form a regular republic. The separate cell of each is finally the place where it passes its change into the aurelia and perfect state. But many species do not separate even then; but are found in their aurelia state all huddled together; numbers of their cases making one confused mass.

One thing more is highly observable in them. The regularity of their marches. They are exactly obedient to their chief. When they change their quarters, one marches single first; two others follow, and keep their bodies very nicely in the same position with his. After these there follows a large party. These regulate their motions by the former: and so the order is continued through the whole company. When the leader turns to the right or left, the whole body does the same instantly. When he stops, they all immediately stop, and march again the moment he advances.

20. The outward covering of the body, is in many animals changed several times: but in few more frequently than the caterpillar.—Most of these throw it off at least once in ten days. Indeed, in the whole insect class, the most numerous of all animated beings, there is scarce one which does not cast its skin, at least once, before it arrives at its full growth. But the caterpillar changes more than his skin; even the outward covering of every, the minutest part of its body. And what they throw off, has the appearance of a complete insect, presenting us with all the external parts of a living animal. If the caterpillar be of the hairy kind, the skin it throws off is hairy, containing the covering of every hair. And even the claws and other parts, that are not visible without a microscope, are as plain in this as in the living animal. But what is more amazing, is, that the solid parts of the head, the skull and teeth are distinguishable therein. The throwing off an old skull and teeth, to make way for new ones, is an act beyond all comprehension! A day or two before, the creature refuses to eat, and walks very slowly, or not at all. He turns from side to side, and often raises his beak, and gently depresses it again. He frequently raises his head, and strikes it down rudely against any thing he stands upon. Frequently the forepart of the body is raised from the place, and thrust very briskly backward and forward, three or four times together. There are likewise distinct motions within every ring. These are severally inflated and contracted alternately, by which the skin is loosened from them; till by this means, and its remaining without food, the body is quite disengaged from its covering.

When this time approaches, all the colours of the skin grow faint, and loose their beauty, receiving no nourishment from the body.—And as the creature continues swelling and shrinking, the skin, being no longer supple, cracks along his back. The crack always begins at the second or third ring from the head. As it opens the new skin is seen within. This opening he easily enlarges, thrusting his body like a wedge, out of the slit, till he lengthens it through four rings. Then he has room to draw out the whole body. First, the head is by several motions loosened, drawn out of the old skull, and raised through the crack: this is then laid softly on the old skin of the part. By the same motions the tail end is disengaged, drawn out, and laid smoothly on the old skin. It takes the animal several days to prepare for the last operation. But when the crack is once made, the whole remaining work is done in less than a minute.

The hairs found on the cast skins of the hairy caterpillars seem at first, like the other part of the exuviæ, to be only the covering of the hairs enclosed. But that is not the case. They are solid things themselves, not barely coverings. In truth, the creature when first

hatched has all its skins perfectly formed, one under another, each furnished with its hairs, so that the old ones fall off with the old skins. And probably the erecting these is one great means of forcing off the old skins.

Perhaps the same sort of mechanism is used even by those caterpillars which do not appear to be hairy. For they really are so, as the microscope shews. When the upper skin of one just ready to change, is slit longitudinally in the place where the crack would be, the skin may be taken off; and it is easily seen how the new one lies below. The hairs are disposed in the nicest manner, for lying smooth under the upper skin. They grow in separate tufts, which never lie one upon another, but together form one surface.

It is remarkable that immediately after this change, they appear much larger than they did before. And they really are so. The very head and skull are greatly larger than before the change. The operation of the cray-fish in changing its shell, may explain this. This also is found considerably larger, when out of the shell than before. In both cases, the body had grown so much, that it was too big for its covering. However, while it remained in it, the parts were compressed, and forced to lie in that narrow room. But as soon as that covering is off, every part distends itself to its proper size.

Indeed, so large a skull, being a hard substance in the caterpillar, could not have been compressed into a smaller. But the fact is, the new skull never hardens till the change approaches, and then imperfectly. At the same time it necessarily takes, from the place it is in, an oblong form. In this shape it is found a few hours before the old skin is cast off; not enclosed within it, but extended under the skin of the first ring of the body. When the old skull is thrown off, the new one soon hardens, and takes its proper figure.

We call the creature hatched from the egg of a butterfly, a caterpillar. But it is a real butterfly all that time.* A caterpillar changes

* The change from a caterpillar to a butterfly was long esteemed a real metamorphosis, but this is not the case. The egg of the butterfly produces a butterfly with all the lineaments of its parent; only these are not disclosed at first, but for a great part of the animal's life are covered with a case or muscular coat, with legs for walking, which only suit it in this state, the nourishment taken in at the mouth, is conveyed to the included animal; and after a proper time this covering is thrown off, and the butterfly, (which might have been at any time discovered while in this state, by means of the microscope,) appears in its proper form.

There is no sign of sex in the animal while in the caterpillar state: the propagation of the species is the business of the creature in its ultimate perfection; and till it attains to that, the generative parts are never unfolded. One female after impregnation by the male, will produce from 400 to 600 eggs. It is an astonishing instinct which these creatures possess, the manner of depositing their eggs: the most appropriate situations are chosen for this purpose: if the animal is to be

its skin four or five times, and when it throws off one, appears in another of the same form. But when it throws off the last, it is now so perfect, as to need no farther nourishment, so there is no farther need of teeth, or any other parts of a caterpillar.

It is plain from hence, that the change of a caterpillar into an aurelia, is not the work of a moment, but is carrying on from the very time of its hatching from the egg. But while the butterfly lies in the body of the caterpillar, its wings are long and narrow, and wound up into the form of a cord, and the feelers are rolled up on the head. The trunk also is twisted up, and laid on the head, but in a very dif-

produced in the present season, the eggs are deposited on the leaves of such trees, as will afford the seasonable nourishment. But if the production is not to take place till the following spring, the eggs are deposited in such a manner, as is best calculated to secure them from the rigours of the intervening season. There are some species which devour one another. M. Reaumer gives an instance of this in 20 caterpillers of the oak which he kept in a box, and which he supplied with plenty of their natural food: yet their numbers daily decreased, till at last there remained only one.

The caterpillar may justly be considered as a walking egg, which is ultimately to produce the proper animal; and its various transmutations, is the process of hatching. But what is most surprising, some species deposit their eggs in the bodies of other species, and while the recipient animal is feeding voraciously for its own support, the injected animal, is feeding upon it, and literally eating it up alive. The beautiful cabbage caterpillar is one of those unhappy kinds, which are frequently infested with these intestine enemies.

Various methods have been invented to destroy these devouring vermin in gardens, orchards, nurseries, &c. some have boiled together, rue, wormwood, and tobacco, of each equal parts, in common water and sprinkled it upon the trees with good success. This method would do very well where there are but few trees: but the best method probably would be to kindle a small charcoal fire to the windward of the trees to be operated upon, and throw upon the burning coals some brimstone. Whenever the fumes of the brimstone reach the caterpillars the consequence is certain destruction to the creatures; and prevents the butterflies from depositing their eggs for that season. The best time for this operation, would be early in the spring when the flies first make their appearance. Some have made use of another expedient. They have discharged small quantities of gunpowder from a musket or fowling-piece at the nests of the caterpillars, and by this means destroyed them. In the Journal Œconomique, the following is said to be an infallible remedy, to prevent the caterpillars from advancing into an enclosure; sow the borders of the enclosure with hemp, and although the neighbourhood is infested with caterpillars, the space enclosed by the hemp will be perfectly free, as not one of the vermin will approach it. In Switzerland they have a curious method of destroying the caterpillars on the trees, they make a pouch or bag, and digging up an ant's nest put it therein, and hang it on a branch of the tree. The ants making their escape from this, by an aperture contrived on purpose, seek to regain their liberty by descending the tree, but are prevented by a girt of wet clay, or soft pitch, which is previously plastered round the trunk, on purpose, in consequence of which, compelled by hunger, they fall upon the caterpillars and devour them

ferent manner from what it is in the perfect animal, or indeed in the aurelia.

A butterfly then, in all its parts, is in the caterpillar in all its states. But it is more easily traced, as it comes nearer the time of being changed into an aurelia. The very eggs hereafter to be laid by the butterfly, are to be found not only in the aurelia, but even in the caterpillar, all arranged in their natural, regular order. In the caterpillar, indeed they are transparent: but in the aurelia they have their proper colour.

As soon as the limbs of the butterfly are fit to be exposed to the more open air, they are thrown out from the body of the caterpillar, surrounded only with thin membranes. And as soon as they arrive at a proper degree of strength and solidity, they break through these, and appear in their perfect form.

The animal then creeps a little on, and there rests; the wings being quite folded up. But by degrees they expand, and in less than half an hour appear in all their beauty.

In the beginning of May, 1737, the cornel trees, near Monaghan in Ireland, appeared covered with small caterpillars, employed partly in feeding on the leaves, partly in crawling over the bark of the tree. Each as it crawled, left a fine thread sticking to the bark. By the end of May, there was not a leaf on any of the trees, except a few reserved for a curious purpose. But instead of the green, a white clothing covered the whole bark from the ground, to the point of the smallest twigs, and that so glossy, that it shewed, in the sun, as if it was cased in burnished silver. Then they covered with the same all the ash, beech, lime, yea the very weeds that grew near them.

But how did they travel from tree to tree? Many crawled along the ground. But many had a quicker way. They hung by their own threads from the utmost branches of the tree, so that a small breeze wafted them to the next tree, as spiders pass from one bush to another.

As they made no use of the threads left behind them, probably they wrought for no other purpose, than to rid themselves of that glutinous matter, out of which it was spun.

In the beginning of June, they retired to rest. Their manner of executing this, was very ingenious. Some chose the under side of the branches, just where they spring from the trunk, that they might be defended from the water, which in a shower, running down the bark of the tree, is parted by the branches, and sent off on each side. Here they draw their threads across the angle made by the trunk and branch: and crossing those with other threads, make a strong covering. Within this they place themselves lengthways among the threads, and rolling their bodies round, spin themselves into little hammocks,

in the mean time shrinking into half their length. These hammocks, being suspended by the transverse threads, do not press each other. That they may take up the less room, they lie parallel to each other, in the most convenient order possible. Others, still more ingenious, fasten their threads to the edge of the leaves which they had saved for that purpose: and with that slender cordage pulling in the extremities of the leaves, draw themselves into a kind of purse, within which they form the same sort of work, and lay themselves up as above. They lay themselves up in great numbers together, both because many were necessary to the work of providing a common covering, and also to keep one another warm, while preparing for the great change.

Between the worm thus laid up, and the hammock enclosing it, there is a tough, brown shell, probably formed of some glutinous matter, transuding through the pores. In the end of June, they gnaw through the shells and hammocks, and come forth a most beautiful fly. After its resurrection, it needs no food. Those that came out in a room, lived as long there as the rest did abroad. After awhile several of them discharged a drop of brown liquor, probably containing the egg. But as it was not lodged in a proper receptacle, it produced no worm the next year.

As the cornel only supplies this worm with food, so it is the only nurse of its egg. There is not an animal or a vegetable, but yields habitation and food to its peculiar insect. The scheme of life begins in vegetation: and whenever nature produces vegetables, she obliges them to pay for their nourishment, to certain animals which she billets upon them. Each of these again, is to diet and lodge another set of living creatures. This just community in nature, which suffers nothing to subsist merely for itself, is found not only every where on the earth, but likewise every where in the waters. By microscopes we discover an infinity of little creatures, feeding on the floating vegetables, or on one another. Indeed, as to the sea, we know only what happens near the shores, where we find vegetables of various kinds, which breed and nourish a like variety of insects. These, with a multitude of others bred in the mud, are the prey of the smaller kinds of fish, and they again of a greater. That this scheme of nature, found every where else, dives into the depths of the ocean, we may gather from the wonderful kind of fishes, washed up by the storms now and then from the deep waters.

Now it is on the cornel alone, that the worms we have spoken of can be propagated and fed. The specific qualities with which its juices are impregnated, are peculiarly suitable to this insect. If these reside in the essential oil of the plant, this, as well as the other insects, subsisting on vegetables, have the skill to extract, nicer than

any chemist can do, the essential oil of each plant, nothing else therein, being of a nature sufficiently peculiar, either to assist the propagation, or supply the nourishment of the insect.

21. The ANT lays eggs like flies, from which are hatched small worms without legs. These are sharp at one end, and blunt at the other: after a short time they change into a large white aurelia, vulgarly called ants' eggs: whereas they are larger than the ants themselves. They move these at their pleasure. When an ant's nest is disturbed, and the aurelia scattered abroad, the ants are at infinite pains to gather them and make them a nest again. Nay, those of one nest will often do this for the aurelia of another.

At the bottom of an ant's nest, which is built with small pieces of dry earth, there is always a large quantity of eggs, worms, and aurelia. The aurelia are covered only with a thin skin, and if opened shew the ant in its several stages toward perfection.

In every nest, as in every bee-hive, there are three kinds of the insect: males, females, and working ants, or labourers. These last are neither male nor female, nor have any business, but taking care of the young brood. Male ants have four wings and three lucid points on their head, and their eyes are larger than those of the female, or labourers. They are not found in the nests at all seasons, but only at particular times. It seems they are killed, like drone bees, as soon as the season for impregnating the females is over.

The body of the female is larger and thicker than that of the male, or labourer; and contains a great number of eggs placed in regular lines. She has also three lucid points on her head, which seem to be three eyes.

The ant examined by the microscope, appears a very beautiful creature. Its head is adorned with two horns, each having twelve points. Its jaws are indented with seven little teeth, which exactly tally. They open sideways exceedingly wide, by which means the ant is often seen grasping and carrying away bodies of three times its own bulk. It is naturally divided into the head, the breast, and the belly, each joined to the other by a slender ligament. From the breast proceed three legs on each side. The whole body is cased over with a sort of armour, so hard as scarce to be penetrated by a lancet, and thick set with shining, whitish bristles.

They bring out not corn, but their young every day, and spread them near their nest, in little heaps, on a kind of dry earth, provided for that purpose. They carry them back at night. But, it is observed, they never bring them out, unless in a day that promises to be fair. In the prognostics of this they shew great sagacity. Where it is dangerous to expose them in the day time, by reason of the birds,

they vary their rule, bringing them out in the night, and carrying them back in the morning.

They do not eat at all in winter, but sleep like most other insects. There is a straight hole in every ant's nest, about half an inch deep; after which it goes sloping into their magazine, which is a different place from that where they eat and rest. Over the hole they lay a flat stone or tile, to secure them from their great enemy, the rain. In a fair day the hole is open; but when they foresee it will rain, and every night, the cover is drawn over, with great ingenuity as well as labour. Fifty of the strongest of them surround the stone, and draw and shove in concert. The like pains they take every morning to thrust it back again.

An ant seldom goes into any nest but her own: if she did, she would be severely punished. And if she returned again after this warning, the others would tear her in pieces. Therefore they never attempt it, but in the last extremity; sometimes they will rather suffer themselves to be taken.

Ants do not bite, as is vulgarly supposed. But red ants have a sting, which expresses a corrosive liquor, and raises a slight inflammation. The black ants have no sting.

On opening an ant-hill, a great number of eggs is usually found. They look like the scatterings of fine salt, and are too minute to be seen distinctly by the naked eye. Through a microscope they appear like the eggs of small birds, and are as clear as the air-bladder of fishes. They lie in clusters under cover of some light earth. The ants seem to brood over them, till every granule is hatched into a worm, not much larger than a mite. In a short time these turn yellowish and hairy, and grow to near as big as their parent. They then get a whitish film over them, and are of an oval form. If this cover be opened after some days, all the lineaments of an ant may be traced; though the whole is transparent, except the eyes, which are two dark specks.

The care these creatures take of their young is amazing.—Whenever a hill is disturbed, all the ants are found busy, in consulting the safety, not of themselves, but of their offspring. They carry them out of sight as soon as possible; and will do it over and over, as often as they are disturbed. They carry the eggs and worms together in their haste; but as soon as the danger is over, they carefully separate them, and place each by themselves, under shelter of different kinds, and at various depths, according to the different degrees of warmth which their different states require.

In the summer they every morning bring up the aurelia near the surface of the earth: and from ten in the morning till about five in

the afternoon, they may be found just under the surface. But if you search at eight in the evening they will be found to have carried them all down. And if rainy weather be coming on, they lodge them at least a foot deep.

Though ants unite in colonies, in such places as are agreeable to their different natures, yet they often vary their residence. But the several species never intermix, though they will be good neighbours one to another.

Their architecture is adjusted with remarkable art. The whole structure is divided into numerous cells, communicating with each other by small subterraneous channels, which are circular and smooth. They carry on all their works by means of their double saws, and the hooks at the extremity of them.

A colony from the latter end of August, to the beginning of June, consists of a female, and various companies of workers: and besides these, in the latter end of June, all July and part of August, of a number of winged ants.

The labouring ants, being of no sex, are wholly employed in providing for the young, which the queen deposits in the cells. In whatever apartment she is present, universal joy is shewn. They have a particular way of skipping, leaping, prancing, and standing on their hind legs. Some walk gently over her, others dance round her, all express their loyalty and affection; of all which you may be convinced in a few moments, by placing the queen and her retinue under a glass.

The queen lays three different sorts of eggs, male and female, in spring, neutral in July and part of August. The common ants then brood over them in little clusters, and remove them to and fro, for a just degree of heat. The young disengage themselves from the membranes that enclose the eggs, just as the silk-worms do. The female eggs, put on the form of worms, some time in February; the male, by the latter end of March, the neutral by September. The first summer they grow little, and less in winter. In the beginning of April, the second year, they visibly increase every day. By the end of May the male and female attain their full growth, and are ready for another change. This long continuance of ants in the vermicular state, has nothing like it in any other class of insects.—The vermicles in a few days infold themselves in a soft silken covering, and so commence aurelias, which are commonly mistaken for ants' eggs. As soon as they tend to life, the workers give them air, by an aperture in the end of the covering. This they gradually enlarge for a day or two, and then take out their young.

There is a larger and a smaller sort of winged ants, the latter male, the former female. Those females, which escape being de-

voured by other creatures, become queens, and give birth to new colonies.

In all other insects the loss of their wings lessens their beauty, and shortens their lives. But ants gain by that loss: this being the prelude of their ascending the throne.

The young are fed by the juices of most sorts of fruits, which the labourers extract, and receive into their own stomach; where they are prepared, and afterwards transfused into the tender vermicles.

Perhaps in warm climates, ants do not pass the winter in sleep, as they do with us. If so they need a store of food, which in our climate is quite needless. Accordingly those who have accurately examined their most numerous settlements, could never find out any reservoir of corn or other aliments. And they that have carefully observed their excursions from, and return to their colonies, could never observe that they returned with any wheat, corn, or any other vegetable seed: though they would eagerly attack a pot of honey, or a jar of sweetmeats.

But is it not said, Prov. vi. 8. "She provideth her meat in the summer, and gathereth her food in the harvest?" It is: but this does not necessarily mean any more, than that she collects her food in the proper season. Nor is any thing more declared, ch. xxx. 35. than that ants carry food into their repositories. That they do this against winter, is not said: neither is it true in fact.

In England, ant-hills are formed with but little apparent regularity. In the southern provinces of Europe, they are constructed with wonderful contrivance. They are generally formed in the neighbourhood of some large tree and a stream of water. The one is the proper place for getting food; the other for supplying the animals with moisture, which they cannot well dispense with. The shape of the ant-hill is that of a sugar-loaf, about three feet high, composed of various substances; leaves, bits of wood, sand, earth, bits of gum, and grains of corn. These are all united into a compact body, perforated with galleries down to the bottom, and winding ways within the structure. From this retreat to the water, as well as to the tree, in different directions, there are many paths worn by constant assiduity, and along these the busy insects pass and repass continually; so that from May or the beginning of June they work continually till the bad weather comes on.

The chief employment of working ants is in finding a sufficiency of food. They live upon various provisions, as well of the vegetable as the animal kind. Small insects they kill and devour; sweets of all kinds they are particularly fond of. They seldom, however, think of their community till themselves are first satiated. Having found

a juicy fruit, they swallow what they can, and then tearing it in pieces, carry home their load. If they meet with an insect above their match, several of them will fall upon it at once, and having torn it to pieces, each will carry off a part of the spoil. If they meet with any thing that is too heavy for one to bear, and yet which they are unable to divide, several of them endeavour to force it along, some dragging, others pushing. If any one of them makes a lucky discovery, it immediately gives advice to others, and then, at once, the whole republic put themselves in motion.* If in these struggles one of them happens to be killed, some survivor carries him off to a great distance, to prevent the obstructions his body might give to the general spirit of industry.

In autumn they prepare for the severity of winter, and bury their wheat as deep in the earth as they can. It is now found that the grains of corn, and other substances with which they furnish their hill, are only meant as fences to keep off the rigour of the weather. They pass four or five months without taking any nourishment, and seem to be dead all that time. It would be to no purpose therefore for ants to lay up corn for the winter, since they lie all that time with-

* There is one circumstance respecting ants, which has generally been overlooked by naturalists, which is truly admirable. It is a certain portion of the community which always act as heralds, or pioners: these always advance on the look out, and which ever way they go, they leave constantly behind them a tract, or a kind of pavement, which consists of a slimy humour emitted from the body of the insect, so that any ant can follow them unerringly whatever direction they take: if they make any discovery of consequence, they immediately return to communicate the intelligence. And this is done in the most effectual manner, either by language or by signs peculiar to themselves as may be presently witnessed, for the ants are directly seen marching in files, straight along the cause way, which has been made by the adventurous poineer; and it is observable that they never miss the path, however eccentric, and winding it may be: but they march on in regular succession, and with the most eager haste, to fetch home the discovered booty. If the booty is large, so as to require much travelling, a party will be dismissed to take surveys, in order to find a nearer route, for transportation, which is frequently done; and no sooner is it announced, than the ants will be seen to quit the old circuitous path, and travel altogether in the new road.

From all the observations which have been made on these wonderful creatures, it is very certain that they are capable of, and subject to a regular government. That they do not run about where they please, and work and spend their time at random: but that they are capable of designing, and acting in concert. They build their nests, and unite their labours with judgment, and they exhibit the social, fraternal, and parental affections in a high degree. If their nest is disturbed and their aureliæ scattered about, they will be at infinite pains to collect them together, and make a nest for them again: any ants will do this, and those of one nest will often take care of the aureliæ of another. Wool newly plucked from the sheep's belly, will stop the course of the ants, or laying saw-dust round the root of a tree, or smearing it round with tar will have the same effect.

out motion, heaped upon each other, and are so far from eating, that they are utterly unable to stir. Thus what authors have dignified by the name of a magazine, appears to be no more than a cavity, which serves for a common retreat when they return to their lethargic state.

But what has been falsely said of the European ant, is true of those of the tropical climates. They do lay up provisions, and as they probably live the whole year, submit to the regulations unknown among the ants in Europe. Those of Africa are of three kinds, the red, the green, and the black; the latter are above an inch long, and in every respect, a most formidable insect. They build an ant-hill from six to twelve feet high, made of viscous clay, and in a pyramid form. The cells are so numerous and even, that a honeycomb scarce exceeds them. The inhabitants of this edifice seem to be under a very strict regulation. At the slightest warning they sally out upon whatever disturbs them, and if they arrest their enemy, he is sure to find no mercy. Sheep, hens and even rats are often destroyed by these merciless insects, and their flesh devoured to the bone. No anatomist can strip a skeleton so clean as they.

If a frog be put into a box with holes bored therein, and the box laid near a nest of ants, they will entirely dissect him, and make the finest skeleton possible, leaving even the ligaments unhurt.

22. One of the most dreadful enemies of the ants is the formica-leo, or ANT EATER; it is soft as a spider, but has in its form some resemblance of a wood-louse. Its body is composed of several rings: it has six legs, four joined to the breast; and the other two to a long part, which may be termed the neck. Its head is small and flat, and it has two remarkable horns, the sixth of an inch long, as thick as a hair, hard, hollow and hooked at the end. At the origin of each of these horns, it has a clear and bright black eye.

He is not able to hunt after prey, nor to destroy large insects. He can only ensnare such as come by his habitation, and of these, few are such as he can manage. All the winged tribe escape by flight, and those that have hard shells are of no use to him. The smallness of the ant, and its want of wings, make it his destined prey. The manner wherein he proceeds is this. He usually encamps under an old wall for shelter, and always chooses a place where the soil is composed of a light, dry sand. In this he makes a pit, in the shape of a funnel, which he does in the following manner:

If he intends the pit to be but small, he thrusts his hinder parts into the sand, and by degrees works himself into it. When he is deep enough, he tosses out with his head the loose sand which is run down, artfully throwing it off, beyond the edges of the pit. Then he lies at the bottom of the small hollow, which comes sloping down to his body.

But if he is to make a larger pit, he first traces a larger circle in the sand. Then he buries himself in it, and carefully throws off the sand, beyond the circle. Thus he continues running down backward, in a spiral line, and throwing off the sand above him all the way, till he comes to the point of the hollow cone, which he has formed by his passage. The length of his neck, and the flatness of his head, enable him to use the whole as a spade. And his strength is so great, that he can throw a quantity of sand, to six inches distance. He likewise throws away the remains of the animals he has devoured, that they may not fright other creatures of the same species.

Where the sand is unmixed, he makes and repairs his pit with great ease. But it is not so where other substances are mixed with it. If when he has half formed his pit, he comes to a stone not too large, he goes on leaving that to the last. When the pit is finished, he creeps up backwards to the stone, and getting his backside under it, takes great pains to get it on a true poise, and then creeps backward with it, to the top of the pit.

We may often see one thus labouring at a stone four times as big as its own body. And as it can only move backward, and the poise is hard to keep, especially up a slope of crumbly sand, the stone frequently slips when near the verge, and rolls down to the bottom. In this case he attacks it again, and is not discouraged by five or six miscarriages; but attempts it again, till at length he gets it over the verge of his place. Yet he does not leave it there, lest it should roll in again, but always removes it to a convenient distance.

When his pit is furnished, he buries himself at the bottom of it in the sand, leaving no part above it, but the tips of his horns, which he extends to the two sides of the pit. Thus he waits for his prey. If an ant walk on the edge of his pit, it throws down a little of the sand. This gives notice, to toss up the sand from his head, on the ant; of which he throws more and more, till he brings him down to the bottom, between his horns. These he then plunges into the ant, and having sucked all the blood, throws out the skin as far as possible. This done, he mounts up the edges of his pit, and if they have suffered any injury, repairs it carefully. He then immediately buries himself again in the centre, to wait for another meal.

This creature has no mouth, but it is through its horns that it receives all its nourishment. And as they are so necessary for its life, nature has provided for the restoring them, in case of accidents: so that if they are cut off, they soon grow again.

When he has lived his stated time, he leaves his pit, and is only seen drawing traces on the sand. After this he buries himself under it, and encloses himself in a case. This is made of a sort of silk with grains of sand cemented together by a glutinous humour which

he emits. But this would be too harsh for his body; so it serves only for the outward covering. He spins within it one of pure, fine, pearl-coloured silk, which covers his whole body. When he has lain some time in this case, he throws off his outer skin, with the eyes, the horns, and all other exterior parts, and becomes an oblong worm, in which may be traced the form of the future fly. Through its transparent skin may be seen new eyes, new horns, and all other parts of the perfect animal. This worm makes its way about half out of the case, and so remains, without farther life or motion, till the perfect fly makes its way out of a slit in the back. It much resembles the dragon-fly. The male then couples with the female and dies.

23. The sagacity of BEES, in making their combs, cannot be too much admired. The labour is distributed regularly among them.—The same bees, sometimes carry the wax in their jaws, and moisten it with a liquor which they distil upon it, and sometimes build the walls of their cells. But they that form the cells, never polish them. Others make the angles exact, and smooth the surface. The bits of wax which are scraped off in doing this, others pick up, that none may be lost.

Those that polish, work longer than those that build the walls; polishing not being so laborious a work as building. They begin the comb at the top of the hive, fastening it to the most solid part thereof. Hence they continue it from top to bottom, and from side to side.—The cells are always six sided: a figure which, beside the advantage it has in common with the square, of leaving no vacancies between the cells, has this, peculiar to itself, that it includes a greater space within the same surface than any other figure.

It is a grand question "is there any part of a plant without iron?" It is certain honey is not. And if so delicate an extract from the finest part of flowers, and that farther elaborated in the bowels of the insect: if this be not without iron we may despair of seeing any part so.

The trunk of a working bee is not formed in the manner of a tube by which the fluid is to be sucked up; but like a besom to sweep, or a tongue to lick it away. The animal is furnished also with teeth, which serve in making wax. This substance is gathered from flowers like honey: it consists of that dust or farina which contributes to the formation of plants. Every bee when it collects this, enters into the cup of the flower, particularly such as have the greatest quantities of this yellow farina. As the animal's body is covered over with hair, it rolls itself within the flower, and is soon covered over with dust, which it brushes off with its two hind legs, and kneads into two little balls.

The habitation of bees ought to be very close; and what their hives want from the negligence or unskilfulness of man, they supply by their own industry: so that it is their principal care, when first hived, to stop up all the crannies. For this purpose they make use of a resinous gum, which is more tenacious than wax. When they begin to work with it, it is soft, but it acquires a firmer consistence every day. The bees carry it on their hinder legs, and plaister the inside of their hives therewith. Their teeth are the instruments by which they model and fashion their various buildings, and give them such symmetry. Several of them work at a time at the cells which have two faces. If they are stinted in time, they give the new cells but half the depth which they ought to have; leaving them imperfect, till they have sketched out the cells necessary for the present occasion. The construction of their combs, costs them a great deal of labour: they are made by insensible additions, and not cast at once into a mould as some are apt to imagine. There seems no end of their shaping, finishing and turning them neatly up. The cells for their young are most carefully formed; those designed for drones, are larger than the rest, and that for the queen bee, the largest of all. Honey is not the only food on which they subsist. The meal of flowers is one of their favorite repasts. This is a diet which they live upon during the summer, and of which they lay up a large winter provision. The wax is no more than this meal digested and wrought into a paste. When the flowers are not fully blown, and this meal is not offered in sufficient quantities, the bees pinch the tops of the stamina in which it is contained, with their teeth; and thus anticipate the progress of vegetation. In April and May the bees are busy from morning to evening, in gathering this meal: but when the weather becomes too hot, they work only in the morning. The bee is furnished with a stomach for its wax, as well as for its honey. In the former their powder is altered, digested and concocted into wax; and is then ejected by the same passage by which it was swallowed. Beside, the wax thus digested, there is a large portion of the powder kneaded up for food in every hive, and kept in separate cells for winter provision. This is called by the country people bee-bread; and contributes to the health and strength of the bee during the winter. We may rob them of their honey, and feed them during the winter with treacle, but no proper substitute has yet been found for the bee-bread; without it the animal becomes consumptive and dies.

Honey is extracted from that part of the flowers called the *nectareum*. From the mouth it passes into the first stomach, or honey-bag, which when filled, appears like an oblong bladder. When a bee has filled its first stomach, it returns back to the hive, where it disgorges the honey into one of the cells. It often happens that the

bee delivers its store to some other at the mouth of the hive, and flies off for a fresh supply. Some honey-combs are left open for common use, many others are stopped up, till there is a necessity of opening them. Each of these are covered carefully with wax, so close that the cover seems to be made at the very instant the fluid is deposited within them.

It was formerly thought that bees did not collect honey in the form we see it, but lodged it in their stomachs, till its nature was changed. But we now know that they merely collect it. Many flowers afford it; but beside this, there are two kinds of honey-dews. The one does not fall, but is a mild sweet juice, which having circulated in the vessels of plants, is separated by proper strainers, and exudes on the leaves, though sometimes it is deposited on the pith, or in the sugar-canes.

So the leaves of the holm-oak are frequently covered with thousands of small drops, which point out the several pores from which they proceeded, and are no other than pure honey. But it is found only on the old leaves, which are strong and firm, not on the tender ones, which are newly come forth: although the old are covered by the new ones, and so sheltered from any thing that could fall from above. Mean time the leaves of the neighbouring trees, have no moisture upon them: whereas, if it fall as a dew, it would necessarily wet all the leaves without distinction.

The other kind of honey-dew, springs from a small insect called a VINE-FRETTER: the excrement of which, is the most delicate honey in nature. They settle on branches of trees that are a year old; the juice of which, however harsh at first, becomes in the bowels of the insect equal in sweetness to any honey whatever.

There are two species of these flies, the smaller is green; the other, twice as large, is blackish. Hearing many bees buzzing in a tuft of a holm-oak, upon observing, I found the tuft of leaves and branches covered with drops which the bees collected. Each of the drops was not round, but of a longish oval. I soon perceived from whence they proceeded. The leaves covered with them, were just beneath a swarm of larger vine-fretters; which from time to time raised their bellies, and ejected small drops of an amber colour. I catched some of them on my hand, and found they had the very same flavour with what had before fallen on the leaves. I afterwards saw the smaller vine-fretters eject their drops in the same manner. This is the only honey-dew that falls: and this never falls from a greater height than a branch, where a cluster of these insects can fix themselves.

Ants are as fond of this honey as bees. The large black ants follow the insect which lives on oak and chesnut trees: the lesser at-

tend those on the elder. But as ants cannot suck up fluids like bees, they wait just under the vine-fretters, in order to suck the drop just as it falls.

The vine-fretters afford more honey about midsummer, as the trees are then fullest of juice. The trees, nevertheless, though pierced to the sap in a thousand places, do not seem to be hurt at all.

The sting of a bee or wasp is a curious piece of workmanship. It is a hollow tube, within which, as in a sheath, are two sharp bearded spears. A wasp's sting has eight beards on the side of each spear, somewhat like the beards of fish-hooks. These spears in the sheath, lie one with its point a little before that of the other. One is first darted into the flesh, which being fixed, by means of its foremost beard, the other strikes in too, and so they alternately pierce deeper, the beards taking more and more hold in the flesh: afterward the sheath follows, to convey the poison into the wound. When the beards are lodged deep in the flesh, bees often leave their stings behind, if they are disturbed before they have time to withdraw their spears into the scabbard.

The queen bee is somewhat larger, considerably longer, and of a brighter red than others. Her office is, to direct and lead the swarm, and to raise a new breed. She brings forth ten, fifteen, or twenty thousand young ones in a year: so that she may literally be said to be the mother of her people. In a hive of eight or ten thousand, there is usually but one queen bee.

Drones, or males, have no stings, and are larger and darker coloured than the working bees. The eggs for them are placed in a larger sort of cells. They are also nurses to the young brood.

It is certain bees foresee rain, though we know not how. Hence no bee is ever caught in a sudden shower, unless it be far distant from the hive, or hurt, or sickly.

Thus much may be seen on the outside of the hive. But when we look within, how is the wonder increased! to see so many thousands all busily at work, and with such admirable regularity! Nor is there less wonder in observing the clusters of them, when they take some rest. Their method then is, to get together and hang one to another in vast numbers. When these clusters are large, they are only shapeless heaps; when smaller, they are a sort of festoon or garland, each end being fastened to the branch, and the middle dropping from it. The manner in which they hang is this: each, with one or both of his fore legs, lays hold of one or both of the hinder legs of the bee that is next above it.

Through a glass hive we see, that as the combs are carried down from the top to the bottom of the hive, each is placed parallel to the former, but not touching it, there being a space between for the bees

to walk. These are the public streets, and by means of these they can make use of every cell. There are likewise alleys cut from street to street, through the substance of the several combs.

All the cells are used in common. Some of them contain only honey, and are covered with a lid of wax. These are never touched by any bee. But other cells are open, and a bee is often seen so lodged in one of these, that only its hinder part appears. The meaning hereof is, each of these open cells contain at the bottom a bee worm. Certain bees daily visit these, plunging their heads into the several cells, one after another.

The fruitfulness of the female is the less strange, when we consider the number of the males. In any hive there are, at the season, several hundreds: in some two or three thousand. These are the joint fathers of the numerous offspring, and when they have done their work, are all killed. The wings of the female reach only to the third ring of her body; whereas those of all other bees cover the whole body. But though she is thus easy to be distinguished, yet few have ever seen a queen bee: as she is always close covered in the hive.

Mr. Reaumur, desiring to try how far the accounts given of the homage paid by the others to the queen bee was true, caused a swarm of bees to be swept down into a glass hive. Among these there was one female. She was soon distinguished by her shape, and the shortness of her wings. For awhile she walked alone at the bottom of the hive; the rest seeming to regard nothing but their own safety. The female, after going twice or thrice up the side of the hive, to the top of it, where they were hung, at last going in among the cluster, brought down a dozen with her. Attended with these, she walked along slowly at the bottom of the hive. But the rest continuing at the top, she went again and again, till they all came down and formed a circle about her, leaving her a free passage wherever she turned to walk, and feeding her with the honey they had gathered for themselves.

The hive was large enough for more than their number. However, the female seemed to find it would not be large enough for the family she was to produce. So gathering them all about her, she went out and flew to a neighbouring tree. All followed her, and formed a cluster about her, in the common way.

The bees follow their queen wherever she goes. And if she be tied by one of the legs to a stick, all the swarm will gather in a cluster about her, and by removing the stick may be carried any where.

Nature seems to have informed the common bees that they are to bring up the offspring of this female, therefore they serve her in every thing. If by any means she is dirtied, all the rest try who

shall clean her. And in cold weather they cluster together about her to keep her warm. Nor do they shew this respect to one female only Mr. Reaumur, at several times, put several females marked with different colours, into the same swarm. And all these were, for a time, received as well as the proper female.

The swarm which leaves an old hive, has often three or more females. These have their several followers. And each with her followers, were the number sufficient, would form a distinct swarm. As it is not, they all go into the same hive. But all, except one are soon destroyed. The reason is, the working bees of a hive have enough to do to prepare cells, for lodging the eggs of one female, and it would be impossible for them to prepare twice or thriee that number.

Sometimes in two parts of a swarm, there are more than two female bees. In this case too, as soon as they are lodged in the hive, all are killed but one. Nature designs but one female for each swarm. But as many things may destroy the egg or worm of this single female, it was needful, that provision should be made for accidents. So that there are often twenty females which live to maturity with the bees of one swarm. But one only is then spared, whether they go out with the swarm, or remain within.

As soon as the swarm is gone out, the first work of the remaining bees, is to destroy the young females. These are all immediately killed and carried out of the hive : and it is common, the morning after the going out of a swarm, to see six, eight, or more female bees lying dead at some distance from the hive. What determines the bees in favour of one, is her having eggs ready to be hatched. Accordingly, if new made cells be examined, she will be found the very next day, to have laid eggs in many, if not all. Whereas if the bodies of the rejected females be examined, there will be found either no eggs at all, or eggs so extremely minute, that it must have been a long time before any could have been laid.

It is not at all times, however, that the bees are thus cruel to the supernumerary females ; but only at the time when they are newly established in their habitation, and in want of all things. At other times they are as kind to strange females as to their own. Mr. Reaumur tried the experiment, by putting a strange female into a hive, where the combs were perfect, and filled with honey ; and the bees shewed the same respect to her, as to their proper sovereign.

The bee that comes loaded to any cell, soon discharges his honey into it. No sooner is he gone, than another comes, and so on, till the whole cell is filled. But that which lies uppermost is always of a different appearance from the rest of the honey. It is a kind of

cream, which both keeps the honey moist, and prevents its running out by accident.

This crust or cream was not, as one would think, voided last, but was gathering from the first. For the bee which comes loaded to the cell, does not at once discharge his honey, but entering into it as deep as may be, thrusts out his fore legs, and pierces a hole through the crust. Keeping this open with his feet, he disgorges the honey in large drops from his mouth. He then closes the hole, and this is regularly done by every bee that contributes to the common store.

But every bee that comes loaded to the hive, does not deposit his honey in the cell. They often dispose of it by the way. Instead of going to the cell, they often go to those that are at work, and call them to feed upon the honey they have brought, that they may not be obliged to intermit their work, on the account of hunger. These feed on the store of the friendly bee, by putting their trunk into her mouth, exactly in the same manner as they do into the bottom of flowers.

Some cells in every hive contain honey for immediate consumption, as in case of bad weather. And these are always open at the top. Others contain provision for the winter. These are all closed down with a strong lid, not easily to be removed. Such is the wisdom which the great Author of nature has imparted to some of the most inconsiderable of his creatures!*

* The bee is the most interesting creature of all the insect tribes. They furnish an example of industry, providence, and economy, which is worthy the contemplation of the moralist and the sage. The noble art, by which they supply the most delicious luxury of the table, and other ingredients which serve many important purposes to man, justly excites our admiration, and demands the tribute of veneration and respect; and is it not calculated to excite compunction, to reflect on the base returns we make for their valuable services, by the use of the fatal match, when at the same time, by a very little providence and care, we could more easily possess ourselves of the luscious hoards of the hive, and yet preserve its inhabitants alive and well. This is effected by a very simple contrivance. It is by constructing an outer and an inner box, a little inclining to the pyramidal form, so that the outer box may slide over, and fit snugly to the inner box. For this purpose the inner box should be provided with a ledge all round its bottom, for the outer box to rest upon, and so close as not to admit of maggots or insects. These should be made of boards which are well seasoned, to prevent their shrinking by the force of the weather; the outer box should be well secured by a good coat of paint; the inner box should be furnished with cross sticks by which to secure the combs. When this is done, the bees will commence their labours, and their operations will necessarily be confined within the inner box. When the season for collecting the honey is arrived, which should be pretty early, in order that the bees may have time during the remainder of the season, to procure a fresh supply, the hive may be removed from its place, to a small convenient distance, and the outer box drawn from off the inner box. At this time there should be

24. The kind of sea-shrubs, as they were formerly accounted, usually termed CORALLINES, are in reality no other than cases for various species of insects. A French gentleman was the first who discovered this. Observing a great number of insects lodged in several parts of these marine productions, he soon inferred, that these were only cases made by these creatures for their habitations: and many of them has since been found to be the covers of marine polypi; a strange kind of animal, so nearly partaking the nature of some vegetables, that new, perfect polypi, perpetually grow like branches from the trunk of the parent. Yea, if a polypus be cut in pieces, every piece will grow into a perfect polypus.

A late writer informs us—"At the Isle of Sheppey, I had the opportunity of seeing several branched corallines alive in sea-water, by the help of a commodious microscope, and was fully assured, that these apparent plants were real animals, in their proper cases, which were fixt to the shells of oysters and other small shell-fish. And at Brighthelmstone, I saw those corallines in motion, whose polypi are contained in cups supported by a long stem that appears full of rings,

another inner box, to slip into the outer box, in the same manner as the former, which should also be provided with cross sticks, and the hive in this situation returned to its proper place, where it would have its wonted appearance, as if nothing had happened. The inner box, which is thus taken away, and which is full of honey, should be covered over with branches and leaves of trees, pretty thick, in order that the bees, after leaving it may not readily find it again. These operations may be transacted in the evening after the bees have retired to rest. In the morning at the usual time of resuming the labours of the day, the bees will discover their situation, and will sally in great confusion from the box, and settle on the branches and leaves that surround it. Soon they will take their flight, and repairing straight to their old hive, will alight at, and enter into it as usual, where they will find nothing but an empty inside, and they will immediately commence their labours to furnish and replenish it. But here it is necessary to observe, that it will be a prudent and just precaution, to supply the new vacant hive, with a few pounds of comb well stored with honey: which will serve as a small capital for commencement, and will very much assist and encourage them, in their future operations. By these means the tender-hearted husbandman is put in possession of a box of honey, free from the dead bodies of the bees, and much better and clearer than that procured by their destruction. Add to this, that he is still in possession of his bees, which by the old barbarous method would have all been destroyed. And by the adoption of these humane methods, he will find himself in possession of a greater stock of honey, than he would by the total destruction of a few hives, as he can lay all the hives under a similar contribution.

All this should be done so as not to interfere with the swarming of the hive, and this method of treatment frequently prevents the hive from swarming to such a degree as to reduce its population too much; it has been observed, that the bees have been rendered more healthy, by this method, as they are obliged to be more industrious, in order to replenish their new hive. On the other hand, the bees have been observed to languish and grow sickly, when the hive has been so full, as not to admit of more deposits.

or twisted in form of a screw. In the middle of the transparent stems or cases, I could easily discern the thread like a tender part of the animals. On several parts of these corallines there are little bodies, which through the microscope appear as so many bladders. To the use of these I was quite a stranger before: but I now discovered, they are habitations of young polypes, which are produced here and there on the sides of the parent, as in the fresh-water polypus: only in the marine ones they are protected by this vesicular covering. These vesicles appear at a certain season of the year, according to the different species of corallines, and fall off, like the blossoms of plants, as soon as the polypi arrive at maturity."

But corallines are cases, not of polypes only, but of various sorts of animals: which occasion their being made of various materials, and in a great variety of forms. Some are united closely and compactly together, forming irregular branches, like trees. Others rise in tufts, like the tubular sort of plants, distinct from one another. Some Maltese corallines are of a peculiar kind. The animals enclosed in these, resemble the many-legged spiders, usually known by the name of scolopendra. Their outside coats are formed of an ash-coloured earthy matter, and closely united to an inner coat, which is tough, horny, transparent, and extremely smooth. The cavity of the tube is quite round, though the animal is of a long figure, like a leech extended. It can turn itself in this tube, and move up and down the better to attack and secure its prey.

It has two remarkable arms. The left much larger than the right. These are doubly feathered. The number of its feet on each side of the body exceeds a hundred and fifty.

As barnacles seem to be a medium between birds and fishes, although they more properly belong to the former; so is a polypus (although it is doubtless an animal,) between animals and plants.

In a polypus, life is preserved after it is cut into several pieces, so that one animal is by section immediately divided into two, three, or more complete animals, each enjoying life and continuing to perform the proper offices of its species.

The common operations, both of the animal and vegetable world, are all in themselves astonishing. Nothing but daily experience make us see without amazement, an animal bring forth young, or a tree bear leaves and fruit. The same experience makes it familiar to us, that vegetables are propagated, not only from the seed, but from cuttings. So the willow-twig cut off, and only stuck in the ground, presently takes root, and is as perfect a tree as that whence it is taken. This is common in the vegetable kingdom, and we have a rare example of it in the animal.

One sort of polypus is an aquatic animal, to be found in ditch-water. It is very slender, and has on the forepart several horns, which serve it for legs and arms. Between these is the mouth; it opens into the stomach, which takes up the whole length of the body: indeed the whole body is but one pipe, a sort of gut which opens at both ends.

The common polypus is about three quarters of an inch long; but there are many species of them: some of which can extend themselves to the length of six or seven inches. Even in the same species, the number of legs and arms is not always the same: but they have seldom fewer than six. Both the body and arms may be inflated all manner of ways, and hence it is, that they put themselves into so great a variety of figures.

They do not swim, but crawl on the ground, or on any body they meet with in the waters. They usually fix their posterior end to something, and stretch their bodies and arms into the water. With their arms they catch numberless insects, which are swimming up and down. A polypus, having seized its prey, uses one or more arms to bring it to its mouth. He can master a worm thrice as long as himself, which he swallows whole: and having drawn all that is nutritive from it, then throws out the skin.

"I have cut a polypus in two, between seven and eight in the morning, and before three in the afternoon each part was a complete animal, able to eat a worm as long as itself. If a polypus be cut lengthways, beginning at the head, but not quite to the tail, there is a polypus with two heads, two bodies, and one tail. Some of these heads and bodies may soon be cut lengthways again. Thus I have produced a polypus, with seven heads, seven bodies, and one tail. I cut off the heads of this new hydra, seven others grew up, and each of these cut off became a polypus.

"I cut a polypus cross-ways into two parts, put them together again, and they reunited. I put the posterior part of one, to the anterior of another, they soon united into one polypus, which ate the next day, and soon put forth young ones, from each part.

"As the body of a polypus is but one gut, I have turned it inside out. The inside soon after became the outside, and it fed and multiplied as before. They do not copulate at all; but each polypus has the faculty of multiplying itself; yea, before it is severed from its parent, I have seen a polypus while growing out of the side of its parent, bring forth young ones: nay, and those young ones themselves have also brought forth others."

Cut a polypus across, and the same day the anterior end lengthens itself, creeps and eats. The lower part which has no head, gets one,

forms itself a mouth, and puts forth arms. It is all one, in whatever part of the body it is cut; cut it into three or four parts, and each becomes a complete polypus.

Cut one lengthways, slitting it quite in two, so as to form two half pipes. It is not long before the two sides of them close; they begin at the posterior part, and close upward, till each half pipe becomes a whole one. All this is done in less than an hour, and the polypus, produced from each of those halves, differs nothing from the first, only it has fewer arms. But these too are soon supplied.

But, as strange animals as all polypi are, the clustering polypi are more strange than the rest. One species of these are of a bell-like form. Their anterior part, in which is their mouth, is hollowed inward, and resembles the open end of a bell. Their other extremity ends in a point, to which is fixt a stalk or pedicle. The polypus when it is ready to divide, first draws in its lips into the cavity: it then by degrees grows round, and presently after divides itself into two other round bodies. These in a few moments open, loose their spherical form, and put on that of a bell, or complete polypus. This is the manner in which clustering polypi are multiplied. The whole operation is performed in three quarters of an hour The cluster which they form, rests upon a stem, which is fixt to some other body at its lower extremity, and from it arise other branches: other branches again shoot out from these in different places; from these last other new ones, and so on. At the extremity of each branch, is a polypus. The assemblage of all these branches, with the polypi at their extremities, form a cluster much resembling a tuft of flowers. The stem which carries all the cluster, is capable of a remarkable motion, each branch contracts, when it is touched: each can contract itself alone, though this seldom happens, for in contracting it commonly touches another, which then immediately contracts with it. When the main stem which bears the whole cluster contracts, all the branches contract together, and the whole becomes entirely closed. A moment after the branches and the stem again extend themselves, and the whole cluster recovers its ordinary figure. A cluster is formed thus: a single polypus detaching from the cluster, swims about in the water, till it meets with some proper body, to fix itself upon. It then has a pedicle, but which is no longer than the polypus itself: but it becomes eight or nine times as long in twenty-four hours, and is to be the main stem of the new cluster. In a day after it is fixt, it divides itself into two, each of which in a few hours divide into two more. These soon after put out branches, and all this is reiterated several times. Thus a principal branch is formed, provided with several lateral ones, which afterwards become principal ones, with regard to others that spring from them.

When a cluster is nearly stript of its polypi, the branches are no longer able to contract. When but a few polypi remain, none can contract but those to which they are fixed. Hence it appears, that this motion in the stem and branches of a cluster, is entirely derived from the polypi. Indeed, at first sight, one would imagine that the polypi fixed to the branches of a cluster, spring from them, in the same manner as the leaves, the flowers and the fruit of a vegetable spring from it. On the contrary, the branches composing the clusters of polypi, spring from the polypi, which are their extremities, and these polypi, which at first appear to be fruits, may rather be termed the roots of them.

The nature of corallines, and the mechanism of their polypi, says Dr. Peyssonel, made me conjecture, that it was the same with respect to sponges; that animals nested in the intestines of their fibres, and gave them their origin and growth: but I had not yet seen the insects. Sponges appeared to me only as skeletons, and I at length discovered the worms which form them. They are of four species. 1. The tube-like sponge. 2. The cord-like sponge. 3. The fingered sponge. 4. The honey-comb sponge.

These four kinds only differ in form; they have the same qualities, and are made by the same kinds of worm; they are all composed of hard, firm, dirty fibres, sometimes brittle, separated one from another, having large hollow tubes dispersed through their substance: these tubes are smooth within. These fibres, which consist of the twisted doubles of the sponge, form as it were a labyrinth filled with worms, which are easily crushed: but having carefully torn the sponges, and their gross fibres, I discovered the living worms.

These species of sponge commonly grow upon sandy bottoms. At their origins we perceive a nodule of sand, or other matter almost petrified, round which the worms begin to work, and round which they retire, as to their last refuge, where I had the pleasure of seeing them play, exercise themselves, and retire, by examining them with the microscope.

The worms are about one third of a line thick, and two or three lines in length. They are so transparent that one may discern their viscera through their substance, and the blood may be seen to circulate. They have a small, black head, furnished with two pincers; the other extremity is almost square, and much larger than the head. Upon the back may be seen two white streaks, as if they contained the chyle: these two canals are parallel to each other from the head to the other extremity, where they come together. In the middle, where the belly and viscera ought to be placed, a blackish matter is perceivable, which has a kind of circulation; sometimes it fills all the body of the worm, sometimes it gathers towards the head, or at

the other end, and sometimes it follows the motion of the animal. This vermicular motion begins at the posterior extremity, and ends at the head. They have no particular lodge, they walk indifferently into the tubular labyrinth. These sponges are attached to some solid body in the sea. Some kinds are fixed to rocks, others to heaps of sand, or to pieces of petrified matter; and the sea putting in motion the sand, and the little parcels of broken shells, forces them into the holes of the sponge.

So far the doctor. But still I doubt, whether the worms form the sponge, or only lodge therein, though I think, the former more probable.

The same doubt I have with regard to what follows: "the belemnites is a fossile, a kind of stony shell, which has hitherto perplexed the naturalists of all countries. Strait ones are common in Sweden, Livonia and Germany, those that are curved are more common in France and England. The nuncleus of it seems to be a strait concamerated shell, which is surrounded by a huge solid substance. Now how was this formed? And how is it that some have a nuncleus, others not? Again: how is it that in some, the cavities containing it are very small, in others not visible?

"In order to understand this, we may consider, that many bodies which we always took for vegetable, are really animal. So the several coralline substances, hitherto reputed marine plants, are now generally believed to be the shells of polypi. Is it not then highly probable, that the testaceous tribe in general are generated like flies, the latter from a maggot, the former from a polypus? It must be so with many: and as corals in general seem to be constructed by polypi, are they not the primary state of all, or most of the testaceous tribe? If so, it is almost beyond a conjecture, that the body called a belemnites, (which on being put into acids, is found to ferment in like manner as corals) is formed likewise by a polypus, from which the nucleus seems to be the last state. And does not this concamerated body, of which the belemnites is only the habitation, lead us into the connection and manner of generation, perhaps particular to the testaceous tribe, by remaining within its nidus all its life, whereas the generality quit their nidi as soon as they are able to shift for themselves.

"The POLYPUS is an animal of the vermicular kind: the bodies of some are long and slender, like a fine fibre, extremely tender, and from the head proceed a variety of claws or arms, with which it catches its food, and prepares its habitation. They are of various shapes and textures; according to the species of the animal that is to proceed from them, and very wonderful it is, how so small an animal should form so large a body as the belemnites! Some animals in the

terrestrial parts of the creation, naturally associate together, others seek solitude. The same dispositions we find in the aquatic, then why not among polypi? Is not this evidently seen from the variety of coral bodies? It seems in some as if thousands acted in concert together; in others each acts for itself; of which latter is the belemnites. The shape of the belemnites is generally conic, terminating in a point, and of various colours, according to the juices of the stratum in which it lay; it has usually a seam running down the whole length of it. Its interior constitution seems composed of several crusts, which when broken transversely proceed on rays from the seam to the centre. This seam I take to have been the habitation of the animal in its polypus state, and in which the body was affixed. The animals of the testaceous tribe in general, as they increase in age, increase their shell in thickness, until they have lived their stated time, and that is done by adding a new crust to it, as several, if not all the tubuli, the oysters, and the nautili, witness. By length of time they grow inactive and dead, the effect of extreme old age suffering other marine bodies, as worms and oysters, to affix themselves to their outer coat. The like appearance we frequently meet with on belemnitæ, when the animal within was either waxed old, or dead."

One might enlarge on the analogies which may be found, between the origin of these minute animals, the origin of plants, and that of those other animals, which we are more acquainted with. But we shall be better able to judge of those analogies, when we come to know more both of plants and animals.

The surprising facts which the study of natural history lays before us day by day, may convince us, that the nature of plants and animals, is as yet but very imperfectly known: indeed much more imperfectly, than many have been apt to imagine. All we know, is very little in comparison of what remains unknown. And this consideration, as it should prompt us, still more diligently to inquire after truth, so it should make us exceedingly cautious how we judge of the nature of things from so few principles as we are at present masters of.

25. One circumstance more is worthy our observation, with regard not only to insects, but in some measure to the whole animal creation: namely, the various transformations they undergo. Those kinds of animals which are viviparous, which produce their young alive, undergo the slightest alteration; yet even these have some. Growth itself is the lowest step of this ladder: and this is common to all animals. Man himself, lordly as he is, at his perfect growth, is not only the most helpless at his birth, but continues so, longer than any other member of the animal world. However, except that of growth, he undergoes no considerable alteration in this life.

Quadrupeds undergo a greater change yearly, by the loss and renovation of their outward covering. This change however is gradual, and almost insensible, the latter being of the same substance, and even colour as the former. But there is an exception to this, in those which undergo this change twice in the year, as do the bears, hares and foxes in Greenland, and other extremely cold countries: and the ermins, which are frequent in Yorkshire, and several other parts of England, their hair changes white at the approach of winter, and in spring resumes its former colour.

One class however of viviparous animals undergo a more sudden alteration, namely the serpent kind. These having no hair or fur to loose gradually, cast their whole covering at once, and are so dexterous therein, though they have neither feet nor claws, that their whole skins are frequently found entire, without even the cornea or outward case of the eyes, which accompanies the other exuviæ, being broken.

Next to these are oviparous animals. These make their first appearance in a state of entire inaction, but being gradually ripened by natural or artificial heat, burst out, some in their complete state, as lizards, spiders and fish in general: and others, as birds, requiring, like viviparous animals, the addition of the extrementitious parts. Almost all the species of these, which we know, need the same farther change with the viviparous. All birds moult their feathers, and many in cold countries change the colour of them in winter. Lizards drop their skins like snakes; one kind of them, water newts, every two or three weeks. Spiders, crabs, and all whose outward covering is crustaceous, and therefore incapable of distension, cast their shells once a year, at which time nature provides them with such supplementary juices, by a kind of exudation from their pores, as form a new shell beneath.

Proceed we to those animals, whose transformations are more complete, which being fully possest of life in one figure, afterwards assume another, or being first in one, afterwards inhabit a quite different element.

To give an instance of each, the egg of a frog being laid in the water, produces a lively animal which we call a tadpole. He has a thin slimy tail, which steers him in the water, in which he wholly resides. But after awhile, legs and feet burst through the skin, the tail drops off, and he is a perfect quadruped. He leaps upon the earth, and ranges over that ground, on which some time since it would have been death to him to be cast.

The beetle class is an instance of the other change, and particularly the cock-chaffer. The female deposits her egg below the surface of the earth, which hatches into a grub, with two or three pair of strong

forceps, whereby it is enabled to force its way through the mould where it was lodged, and to cut and tear in pieces for its nourishment any small roots which come in its way. After staying here two whole years, a shelly covering forms over its soft body, a pair of fine wings grow on its back, to secure which from danger, when not used, a pair of strong cases are provided. And now forcing his way out of the ground, he becomes a lively inhabitant of the air.

CHAPTER VI.

GENERAL OBSERVATIONS AND REFLECTIONS.

1. AS to the number of animals, the species of beasts, including also serpents, are not very numerous. Such as are certainly known and clearly described, are not above a hundred and fifty. And yet probably not many, that are of any considerable bigness, have escaped the notice of the curious. The species of birds, known and described, are near five hundred, and the species of fishes, secluding shell-fish, as many: but if the shell-fish are taken in, above six times the number. How many of each genus remain undiscovered, we cannot very nearly conjecture. But we may suppose, the whole sum of beasts and birds to exceed by a third part, and fishes by one-half, those that are known.

The insects, taking in the exsanguious, both terrestrial and aquatic, may for number vie even with plants themselves. The exsanguious alone, by what Dr. Lister has observed and delineated, we may conjecture cannot be less, if not many more, than three thousand species. Indeed this computation seems to be much too low; for if there are a thousand species in this island and the sea near it; and if the same proportion hold between the insects native of England, and those of the rest of the world, (about a tenth,) the species of insects on the whole globe, will amount to ten thousand.

Now if the number of creatures even in this lower world, be so exceeding great: how great, how immense must be the power and wisdom of him that formed them all! For as it argues far more skill in an artificer, to be able to frame both clocks and watches, and pumps, and many other sorts of machines, than he could display in making but one of those sort of engines, so the Almighty declares more of his wisdom, in forming such a multitude of different sorts of crea-

tures, and all with admirable and unreprovable art, than if he had created but a few.

2. Again, the same superiority of knowledge would be displayed, by contriving engines for the same purposes after different fashions, as the moving clocks or other engines by springs instead of weights: and the infinitely wise Creator, has shewn by many instances, that he is not confined to one only instrument, for the working one effect, but can perform the same thing by divers means. So, though most flying creatures have feathers, yet hath he enabled several to fly without them, as the bat, one sort of lizard, two sorts of fishes, and numberless sorts of insects. In like manner, although the air bladder in fishes seems necessary for swimming, yet are many so formed as to swim without it: as first, the cartilaginous kind, which nevertheless ascend and descend at pleasure, although by what means we cannot tell. Secondly, the cetaceous kind: the air which they receive into their lungs, in some measure answering the same end.

Yet again, though God has tempered the blood and bodies of most fishes to their cold element, yet to shew he can preserve a creature as hot as beasts themselves in the coldest water, he has placed a variety of these cetaceous fishes in the northernmost seas. And the copious fat wherewith their bodies are enclosed, by reflecting the internal heat, and keeping off the external cold, keeps them warm even in the neighbourhood of the pole.

Another proof that God can by different means produce the same effect, is the various ways of extracting the nutritious juice out of the aliment, in various creatures.

In man and beasts, the food first chewed is received into the stomach, where it is concocted and reduced into chyle, and so evacuated into the intestines, where, being mixed with the choler and pancreatic juice, it is farther subtalized, and rendered so fluid, that its finer parts easily enter the mouth of the lacteal veins.

In birds there is no chewing: but in such as are not carnivorous, it is immediately swallowed into the crop, or anti-stomach, which is observed in many, especially piscivorous birds, where it is moistened by some proper juice, and then transferred to the gizzard, by the working of whose muscles, assisted by small pebbles, which they swallow for that purpose, it is ground small, and so transmitted to the intestines.

In oviparous reptiles, and all kind of serpents, there is neither chewing nor comminution in the stomach, but as they swallow animals whole, so they void the skins unbroken, having extracted the nutritious juices. Here, by the bye, we may observe the wonderful dilatability of the throats and gullets of serpents. Two entire adult

mice have been taken out of the stomach of an adder whose neck was no bigger than one's little finger.

Fishes which neither chew, nor grind their meat, do, by means of a corrosive juice in their stomach, reduce skin, bones and all into chyle. And yet this juice shews no acidity to the taste. But how mild soever it tastes, it corrodes all animal substances, as aquafortis does iron.

3. Several eminent men have been of opinion, that all brutes are mere machines. This may be agreeable enough to the pride of man; but is not agreeable to daily observation. Do we not continually observe in the brutes which are round about us, a degree of reason? Many of their actions cannot be accounted for without it: as that commonly noted of dogs, that running before their masters, they will stop at the parting of the road, till they see which way their masters take. And when they have gotten what they fear will be taken from them, they run away and hide it. Nay, what account can be given, why a dog being to leap on a table, which he sees he cannot reach at once, if a stool or chair stands near it, he first mounts that, and thence proceeds to the table?* If he were mere clock work, and his motion caused by a material spring, that spring being once set to work, would carry the machine in a right line, towards the object that put it in motion.

* We may discover daily a most obvious difference in the sagacity, tractability, instinct, and intelligence, of brutes: The difference of their capacities is equally striking with that of the human species. We observe one man towering on the pinnacle of intelligence, while another is grovelling in the first resemblance of its reign. So among the brutes we observe one species full of activity and design, while another scarce seems a subject of animation. The hog exhibits a striking contrast to the ape or the elephant. Pope has this fine exclamation in his essay on man:

> How various instinct in the grov'ling swine,
> Compared, half-reasoning elephant, with thine.

And the sloth or the glutton exhibits a very diminutive character contrasted with the hog. Mr. White in his Natural History, has some excellent observations on this subject. Every hen is in her turn the varigo of the yard, in proportion to the helplessness of her brood; and will fly in the face of a dog, or other animal, in defence of those chickens, which in a few weeks she will drive from her with relentless cruelty. Dams will throw themselves in the way of the greatest danger, in order to avert it from their progeny. The partridge will tumble along before a sportsman in order to draw away the dogs from her helpless covey. In the time of nidification the most feeble birds, will assault the most rapacious. All the hirundines of a village are up in arms at the sight of a hawk, whom they will persecute till he leaves that district. A pair of ravens nestling in the rock of Gibraltar would not suffer a vulture or eagle to rest near their station, but would drive them away with an amazing fury. If you stand near the nest of a bird that has young, she will not be induced to betray them by an inadvertent fondness,

Were it true, that brutes were mere machines, they could have no perception of pleasure or pain. But how contrary is this, to the doleful significations they give, when beaten or tormented? How contrary to the common sense of mankind? For do we not all naturally pity them, apprehending them to feel pain just as we do? Whereas no man is troubled to see a plant torn, or cut, or mangled how you please. And how contrary to scripture? "A righteous man regardeth the life of his beast: but the tender mercies of the wicked are cruel." Prov. xii. 10. The former clause is usually rendered, a good man is merciful to his beast. And this is the true rendering, as appears by the opposite clause, that the wicked is cruel. Cruelty then may be exercised toward beasts. But this could not be, were they mere machines.

4. The natural instinct of all creatures, and the special provision made for some of the most helpless, do in a particular manner demonstrate the great Creator's care.

First, what an admirable principle is the natural affection of all creatures toward their young! By means of this, with what care do they nurse them up, thinking no pains too great to be taken for them, no danger too great to be ventured upon, for their guard and security! How will they caress them with their affectionate notes, put food into their mouths, suckle them, cherish and keep them warm, teach them to pick and eat, and gather food for themselves; and, in a word, perform the whole part of so many nurses, deputed by the sovereign Lord of the world to help such young and shiftless creatures till they are able to shift for themselves!

Other animals, insects in particular, whose offspring is too numerous for the parent's provision, are so generated, as to need none of their care. For they arrive immediately at their perfect state, and so are able to shift for themselves. Yet thus far the paternal instinct, equal to the most rational foresight, extends, that they do not drop their eggs any where, but in commodious places, suitable to their species. And some include in their nests, sufficient and agreeable food, to serve their young till they come to maturity.

And for the young themselves. As the parent is not able to carry them about, to clothe them and dandle them, as a man doth: how admirably is it contrived, that they can soon walk about, and begin

but will wait about at a distance with meat in her mouth for an hour together. Thus many creatures exhibit in a striking manner, a most extraordinary degree of providence and apprehension, for their support and safety, and will select the most convenient and secure places for their nest or retreat, while others will not appear to apprehend the most obvious danger, as the spider when it weaves its web in the parlour, or the insect when it flies in the flame of a lamp.

to shift for themselves! How naturally do they hunt for their teat, suck, pick and take in their proper food!

On the other hand, the young of man, (as their parent's reason is sufficient, to help, to nurse, feed and clothe them) are born utterly helpless, and are more absolutely than any creature, cast upon their parent's care.

Secondly, what admirable provision is made for some of the most helpless creatures, at a time when they must otherwise utterly perish! The winter is an improper season to afford food to insects and many other animals. When the fields, trees, and plants are naked, and the air is chilled with frost; what would become of such animals, whose tender bodies are impatient of cold, and who are nourished only by the produce of the spring or summer? To prevent their total destruction, the wise Preserver of the world has so ordered, that in the first place, those which are impatient of cold, should have such a peculiar structure of body, as during that season, not to suffer any waste, nor consequently need any recruit. Hence many sorts of birds, and almost all insects, pass the whole winter without any food, and most of them without any respiration. It seems all motion of the animal juices is extinct. For though cut in pieces they do not awake, nor does any fluid ooze out at the wound. This sleep therefore is little less than death, and their waking, than a resurrection, when the returning sun revives them and their food together.

The next provision is for such creatures as can bear the cold, but would want food. This is provided against in some, by a long patience of hunger; in others, by their wonderful instinct, in laying up food before hand, against the approaching winter. By some of these, their little treasuries are at the proper season well stocked with provisions. Yea, whole fields are here and there bespread with the fruits of the neighbouring trees laid carefully up in the earth, and covered safe by provident little animals.

5. And what a prodigious act is it of the Creator's indulgence to the poor, shiftless irrationals, that they are already furnished with such clothing, as is proper to their place and business! With hair, with feathers, with shells, or with firm armature, all nicely accommodated, as well to the element wherein they live, as to their several occasions there. To beasts, hair is a commodious clothing; which together with the apt texture of their skin, fit them in all weathers to lie on the ground, and to do their service to man. The thick and warm fleeces of others, are a good defence against the cold and wet, and also a soft bed: yea, and to many a comfortable covering for their tender young.

All the animals near Hudson's Bay, are clothed with a close, soft, warm fur. But what is still more surprising, and what draws all at-

tentive minds to admire the wisdom and goodness of Providence, is, that the very dogs and cats which are brought thither from England, on the approach of winter change their appearance, and acquire a much longer, softer and thicker coat of hair than they originally had.

And as hair is a commodious dress for beasts, so are feathers for birds. They are not only a good guard against wet and cold, but nicely placed every where on the body, to give them an easy passage through the air, and to waft them through that thin medium. How curious is their texture for lightness, and withal close and firm for strength! And where it is necessary they should be filled, what a light, medullary substance are they filled with? So that even the strongest parts, far from being a load to the body, rather help to make it light and buoyant. And how curiously are the vanes of feathers wrought, with capillary filaments, neatly interwoven together, whereby they are sufficiently close and strong, both to guard the body against the injuries of the weather, and to empower the wings, like so many sails, to make strong impulses on the air in their flight.

No less curious is the clothing of reptiles. How well adapted are the rings of some, and the contortions of the skin of others, not only to fence the body sufficiently, but to enable them to creep, to perforate the earth, and to perform all the offices of their state, better than any other covering?

Observe, for instance, the tegument of the earth-worms, made in the completest manner, for making their passage through the earth, wherever their occasions lead them. Their body is made throughout of small rings, which have a curious apparatus of muscles, that enable them with great strength to dilate, extend, or contract their whole body. Each ring is likewise armed with stiff, sharp prickles, which they can open at pleasure, or shut close to their body. Lastly, under their skin there is a slimy juice, which they emit as occasion requires, to lubricate the body, and facilitate their passage into the earth. By all these means they are enabled, with ease and speed, to work themselves into the earth, which they could not do, were they covered with hair, feathers, scales, or such clothing, like any of the other creatures.

How wisely, likewise, are the inhabitants of the waters clothed! The shells of some fishes, are a strong guard to their tender bodies, and consistent enough with their slow motion: while the scales and fins of others afford them an easy and swift passage through the waters.

6. Admirable, likewise, is the sagacity of brute animals in the conveniency and method of their habitations. Their architectural skill herein, exceeds all the skill of man. With what inimitable art do some of these poor, untaught creatures, lay a parcel of rude, ugly

sticks or straws together! with what curiosity do they line them within, yea, wind and place every hair, feather, or lock of wool, to guard and keep warm the tender bodies, both of themselves and their young! And with what art do they thatch over and coat their nests without, to deceive the eye of the spectators, as well as to guard and fence them against the injuries of the weather.

Even insects, those little, weak, tender creatures, what artists are they in building their habitations! How does the bee gather its comb from various flowers, the wasp from solid timber! With what accuracy do other insects perforate the earth, wood, yea, stone itself! Farther yet, with what care and neatness do most of them line their houses within, and seal them up and fence them without! How artificially do others fold up the leaves of trees; others glue light bodies together, and make floating houses, to transport themselves, to and fro, as their various occasions require!

7. Another instance of the wisdom of Him that made and governs the world, we have in the balance of creatures. The whole surface of the terraqueous globe, can afford room and support, to no more than a determinate number of all sorts of creatures. And if they should increase to double or treble the number, they must starve or devour one another. To keep the balance even, the Author of nature has determined the life of all creatures to such a length, and their increase to such a number, proportioned to their use in the world. The life indeed of some hurtful creatures is long: of the lion in particular. But then their increase is exceeding small: and by that means they do not overstock the world. On the other hand, where the increase is great, the lives of those creatures are generally short. And besides this, they are of great use to man, either for food or on other occasions. This indeed should be particularly observed, as a signal instance of Divine Providence, that useful creatures are produced in great plenty; others in smaller numbers. The prodigious increase of insects, both in and out of the waters may exemplify the former observation. For innumerable creatures feed upon them, and would perish, were it not for this supply. And the latter is confirmed by what many have remarked: that creatures of little use, or by their voraciousness pernicious, either seldom bring forth, or have but one or two at a birth.

8. How remarkable is the destruction and reparation of the whole animal creation! The surface of the earth is the inexhaustible source whence both man and beast derive their subsistence. Whatever lives, lives on what vegetates, and vegetables in their turn, live, on whatever has lived or vegetated: it is impossible for any thing to live, without destroying something else. It is thus only that animals can subsist themselves, and propagate their species.

God, in creating the first individual of each species, animal or vegetable, not only gave a form to the dust of the earth, but a principle of life, enclosing in each, a greater or smaller quantity of original particles, indestructible and common to all organized beings. These pass from body to body, supporting the life, and ministering to the nutrition and growth of each. And when any body is reduced to ashes, these original particles, on which death hath no power, survive and pass into other beings, bringing with them nourishment and life. Thus every production, every renovation, every increase by generation or nutrition, supposes a preceding destruction, a conversion of substance, an accession of these organical particles, which ever subsisting in equal number, render nature always equally full of life.

The total quantity of life in the universe is therefore perpetually the same. And whatever death seems to destroy, it destroys no part of that primitive life, which is diffused through all organized beings. Instead of injuring nature, it only causes it to shine with the greater lustre. If death is permitted to cut down individuals, it is only, in order to make of the universe, by the reproduction of beings, a theatre ever crowded, a spectacle ever new. But it is never permitted to destroy the most inconsiderable species.

That beings may succeed each other, it is necessary that there be a destruction among them. Yet, like a provident mother, nature in the midst of her inexhaustible abundance, has prevented any waste, by the few species of carnivorous animals, and the few individuals of each species; multiplying at the same time both the species and individuals of those that feed on herbage. In vegetables she seems to be profuse, both with regard to the number and fertility of the species.

In the sea, indeed, all the species are carnivorous. But though they are perpetually preying upon, they never destroy each other, because their fruitfulness is equal to their depredations.

"Thus, through successive ages stands,
Firm fix'd thy Providential care!
Pleas'd with the works of thine own hands
Thou dost the wastes of time repair."

9. I add a few more reflections on the world in general. The same wise Being, who was pleased to make man, prepared for him also an habitation so advantageously placed, that the heavens and the rest of the universe might serve it both as an ornament and a covering. He constructed likewise the air which man was to breathe, and the fire which was to sustain his life. He prepared also metals, salts, and all terrestrial elements to renew, and maintain throughout all

ages, whatever might be on any account necessary for the inhabitants of the earth.

The same Divine Ruler is manifest in all the objects that compose the universe. It is he that caused the dry land to appear, above the surface of the ocean, that guaged the capacity of that amazing reservoir, and proportioned it to the fluid it contains. He collects the rising vapours, and causes them to distil in gentle showers. At his command the sun darts his enlivening rays, and the winds scatter the noxious effluvia, which if they were collected together might destroy the human race.

He formed those hills and lofty mountains which receive and retain the water within their bowels, in order to distribute it with economy to the inhabitants of the plains, and to give it such an impulse, as might enable it to overcome the unevenness of the lands, and convey it to the remotest habitations.

He spread under the plains, beds of clay, or compact earths, there to stop the waters, which after a great rain, make their way through innumerable little passages. These sheets of water frequently remain in a level with the neighbouring rivers, and fill our wells with their redundancy, or as those subside, flow into them again.

He proportioned the variety of plants in each country, to the exigencies of the inhabitants, and adapted the variety of the soils, to the nature of those plants.

He endued numerous animals with mild dispositions, to make them the domestics of man: and taught the other animals to govern themselves, with an aversion to dependence, in order to continue their species without loading man with too many cares.

If we more nearly survey the animal and vegetable world, we find all animals and plants have a certain and determined form, which is invariably the same. So that if a monster ever appear, it cannot propagate its kind, and introduce a new species into the universe. Great indeed is the variety of organized bodies. But their number is limited. Nor is it possible to add a new genus either of plants or animals, to those of which God has created the germina, and determined the form.

The same Almighty power has created a precise number of simple elements, essentially different from each other, and invariably the same. By these he varies the scene of the universe and at the same time prevents its destruction, by the very immutability of the nature and number of these elements. So that the whole is for ever changed, and yet eternally the same.

Yet if we would account for the origin of these elements, we are involved in endless uncertainty. We can only say, he who has

appointed their different uses in all ages, has rendered those uses infallible, by the impossibility of either destroying or increasing them.

Herein we read the characters of his power, which is invariably obeyed; of his wisdom, which has abundantly provided for every thing; and of his tender kindness toward man, for whom he has provided services equally various and infallible. It is an additional proof of his continual care of his creatures, that though every thing be composed of simple elements, all placed within our reach, yet no power is able to destroy the least particle of them. Nothing but the same cause which was able to give them birth, can annihilate them or change their nature. In truth, the design and will of the Creator, is the only physical cause of the general economy of the world: the only physical cause of every organized body, every germ that flourishes in it; the only physical cause of every minute, elementary particle, which enters into the composition of all.

We must not then expect ever to have a clear and full conception of effects, natures, and causes. For where is the thing which we can fully conceive? We can no more comprehend either what body in general is, or any particular body, suppose a mass of clay, or a ball of lead, than what a spirit, or what God is.

If we turn our eyes to the minutest parts of animal life, we shall be lost in astonishment! And though every thing is alike easy to the Almighty, yet to us it is matter of the highest wonder, that in those specks of life, we find a greater number of members to be put in motion, more wheels and pullies to be kept going, and a greater variety of machinery, more elegance and workmanship (so to speak) in the composition, more beauty and ornament in the finishing, than are seen in the enormous bulk of the crocodile, the elephant, or the whale. Yea, they seem to be the effects of an art, as much more exquisite as the movements of a watch are, than those of a coach or waggon.

Hence, we learn, that an atom, to God, is as a world; and a world but as an atom: just as to him one day is a thousand years; and a thousand years but as one day. Every species likewise of these animalcula may serve to correct our pride, and shew how inadequate our notions are, to the real nature of things. How extremely little can we possibly know, either of the largest or smallest part of the creation? We are furnished with organs capable of discerning, to a certain degree, of great or little only. All beyond is as far beyond the reach of our conceptions, as if it had never existed.

Proofs of a wise, a good and powerful Being are indeed deducible from every thing around us: but the extremely great, and the extremely small, seem to furnish us with those that are most con-

vincing. And, perhaps, if duly considered, the fabric of a world, and the fabric of a mite, may be found equally striking and conclusive.

Glasses discover to us numberless kinds of living creatures, quite indiscernible to the naked eye. And how many thousand kinds may there be, gradually decreasing in size, which we cannot see by any help whatever? Yet to all these we must believe God has not only appointed the most wise means for preservation and propagation, but has adorned them with beauty equal at least to any thing our eyes have seen.

In short, the world around us is the mighty volume wherein God hath declared himself. Human languages and characters are different in different nations. And those of one nation are not understood by the rest. But the book of nature is written in an universal character, which every man may read in his own language. It consists not of words, but things which picture out the Divine perfections. The firmament every where expanded, with all its starry host, declares the immensity and magnificence, the power and wisdom of its Creator. Thunder, lightning, storms, earthquakes and volcanos, shew the terror of his wrath. Seasonable rains, sunshine and harvest, denote his bounty and goodness, and demonstrate how he opens his hand, and fills all living things with plenteousness. The constantly succeeding generations of plants and animals, imply the eternity of their first cause. Life subsisting in millions of different forms, shews the vast diffusion of this animating power, and death the infinite disproportion between him and every living thing.

Even the actions of animals are an eloquent and a pathetic language. Those that want the help of man, have a thousand engaging ways, which, like the voice of God speaking to his heart, command him to preserve and cherish them. In the mean time, the motions or looks of those which might do him harm, strike him with terror, and warn him, either to fly from or arm himself against them. Thus it is, that every part of nature directs us to nature's God.

10. The reader will easily excuse my concluding this chapter, also, with an extract from Mr. Hervey.

"In all the animal world, we find no tribe, no individual, neglected by its Creator. Even the ignoble creatures are most wisely circumstanced, and most liberally accommodated.

"They all generate in that particular season, which supplies them with a stock of provisions, sufficient not only for themselves, but for their increasing families. The sheep yean, when there is herbage to fill their udders, and create milk for their lambs. The birds hatch their young, when new-born insects swarm on every side. So that the caterer, whether it be male or female parent, needs only to alight

on the ground, or make a little excursion into the air, and find a feast ready dressed for the mouths at home.

"Their love to their offspring, while they are helpless, is invincibly strong: whereas the moment they are able to shift for themselves, it vanishes as though it had never been. The hen that marches at the head of her little brood, would fly at a mastiff in their defence. Yet, within a few weeks, she leaves them to the wide world, and does not even know them any more.

"If the God of Israel inspired Bezaleel and Aholiah 'with wisdom and knowledge in all manner of workmanship,' the God of nature has not been wanting, in his instructions to the fowls of the air. The skill with which they erect their houses, and adjust their apartments is inimitable. The caution with which they hide their abodes from the searching eye, or intruding hand, is admirable. No general, though fruitful in expedients, could build so commodious a lodgment. Give the most celebrated artificer the same materials, which these weak and unexperienced creatures use; let a Jones or a Demoivre have only some rude stones or ugly sticks, a few bits of dirt or scraps of hair, a lock of wool, or a coarse sprig of moss; and what works could they produce?

"We extol the commander, who knows how to take advantage of the ground; who by every circumstance embarrasses the forces of his enemy, and advances the success of his own. Does not this praise belong to the feathered leaders, who fix their pensile camp, on the dangerous branches that wave aloft in the air, or dance over the stream? By this means the vernal gales rock their cradle, and the murmuring waters lull the young, while both concur to terrify their enemies, and keep them at a distance. Some hide their little household from view, amidst the shelter of entangled furze. Others remove it from discovery, in the centre of a thorny thicket. And by one stratagem or other they are generally as secure as if they intrenched themselves in the earth.

"If the swan has large sweeping wings, and a copious stock of feathers, to spread over his callow young, the wren makes up by contrivance what is wanting in her bulk. Small as she is, she will be obliged to nurse up a very numerous issue. Therefore with surprising judgment she designs, and with wonderful diligence finishes her nest. It is a neat oval, bottomed and vaulted over with a regular concave: within made soft with down, without thatched with moss, only a small aperture left for her entrance. By this means the enlivening heat of her body is greatly increased during the time of incubation. And her young no sooner burst the shell, than they find themselves screened from the annoyance of the weather, and comfortably reposed, till they gather strength in the warmth of a bagnio.

"Perhaps we have been accustomed to look upon insects, as so many rude scraps of creation. But if we examine them with attention they will appear some of the most polished pieces of divine workmanship. Many of them are decked with the richest finery. Their eyes are an assemblage of microscopes; the common fly, for instance, who surrounded with enemies, has neither strength to resist, nor a place to retreat to secure herself. For this reason she has need to be very vigilant, and always upon her guard. But her head is so fixed that it cannot turn to see what passes, either behind or around her. Providence, therefore, has given her, not barely a retinue, but more than a legion of eyes, insomuch that a single fly is supposed to be the mistress of no less than eight thousand. By the help of this truly amazing apparatus, she sees on every side, with the utmost ease and speed, though without any motion of the eye, or flexion of the neck.

"The dress of insects is a vesture of resplendant colours, set with an arrangement of the brightest gems. Their wings are the finest expansion imaginable, compared to which, lawn is as coarse as sackcloth. The cases which enclose their wings, glitter with the finest varnish, are scooped into ornamental flutings, are studded with radiant spots, or pinked with elegant holes. Not one but is endued with weapons to seize their prey, and dexterity to escape their foe, to despatch the business of their station, and enjoy the pleasure of their condition.

"What if the elephant is distinguished by his huge proboscis? The use of this is answered in these his meaner relations, by the curious feelers, remarkable, if not for their enormous size, yet for their ready flexion and quick sensibility. By these they explore their way in the darkest road: by these they discover and avoid whatever might defile their neat apparel, or endanger their tender lives.

"Every one admires the majestic horse. With what rapid career does he bound along the plain! Yet the grasshopper springs forward with a bound abundantly more impetuous. The ant too, in proportion to its size, excels him both in swiftness and strength; and will climb precipices, which the most courageous courser dares not attempt to scale. If the snail moves more slowly, she has, however, no need to go the same way twice over: because, whenever she departs, wherever she removes, she is always at home.

"The eagle, it is true, is privileged with pinions that outstrip the wind. Yet neither is that poor outcast, the groveling mole, disregarded by divine Providence. Because she is to dig her cell in the earth, her paws serve for a pick-axe and spade. Her eye is sunk deep into its socket, that it may not be hurt by her rugged situation. And as it needs very little light, she has no reason to complain of her dark abode. So that her subterranean habitation, which some might

call a dungeon, yields her all the safety of a fortified castle, and all the delights of a decorated grot.

"Even the spider, though abhorred by man, is the care of all-sustaining Heaven. She is to support herself by trepanning the wandering fly. Suitably to her employ, she has bags of glutinous moisture. From this she spins a clammy thread, and weaves it into a tenaceous net. This she spreads in the most opportune place. But knowing her appearance would deter him from approaching, she then retires out of sight. Yet she constantly keeps within distance; so as to receive immediate intelligence when any thing falls into her toils, ready to spring out in the very instant. And it is observable, when winter chills the air, and no more insects rove through it, knowing her labour would be in vain, she leaves her stand, and discontinues her work.

"I must not forget the inhabitants of the hive. The bees subsist as a regular community. And their indulgent Creator has given them all implements necessary either for building their combs, or composing their honey. They have each a portable vessel, in which they bring home their collected sweets: and they have the most commodious store-houses, wherein they deposit them. They readily distinguish every plant, which affords materials for their business: and are complete practitioners in the arts of separation and refinement. They are aware that the vernal bloom and summer sun continue but for a season. Therefore they improve to the utmost every shining hour, and lay up a stock sufficient to supply the whole state, till their flowery harvest returns.

"If the master of this lower creation is ennobled with the powers of reason, the meanest classes of sensitive beings, are endued with the faculty of instinct: a sagacity which is neither derived from observation, nor waits the finishing of experience: which without a tutor teaches them all necessary skill, and enables them without a pattern to perform every needful operation. And what is more remarkable, it never misleads them either into erroneous principles, or pernicious practices: nor ever fails them in the most nice and difficult of their undertakings.

"Let us step into another element, and just visit the watery world. There is not one among the innumerable myriads, that swim the boundless ocean, but is watched over by the Sovereign eye, and is supported by his Almighty hand. He has condescended even to beautify them. He has given the most exact proportion to their shape, the gayest colours to their skin, and a polished surface to their scales. The eyes of some are surrounded with a scarlet circle: the back of others diversified with crimson stains. View them when they glance along the stream, or when they are fresh from their native

brine, the silver is not more bright, nor the rainbow more glowing than their vivid, glossy hues.

"But as they have neither hands nor feet, how can they help themselves, or escape their enemies? By the beneficial, as well as ornamental furniture of fins. These when expanded, like masts above, and ballast below, poise their floating bodies, and keep them steadily upright. They are likewise greatly assisted by the flexibility and vigorous activity of their tails; with which they shoot through the paths of the sea, swifter than a vessel with all its sails. But we are lost in wonder at the exquisite contrivance and delicate formation of their gills: by which they are accommodated, even in that dense medium, with the benefits of respiration! A piece of mechanism this, indulged to the meanest of the fry: yet infinitely surpassing, in the fineness of its structure and operation, whatever is curious in the works of art, or commodious in the palaces of princes."

PART THE THIRD.

OF PLANTS AND FOSSILS.

CHAPTER I.

OF PLANTS.

1. BY plants we mean organized bodies, destitute of sense and motion, fixed in the earth, and drawing their nourishment from it by their roots. Touching these, we may consider, first, the structure of their parts, and then their nutrition and generation.

2. The parts of which they are composed are either liquid or solid. The liquid are usually divided into juices and tears. The juice is to the plant, what blood is to an animal, and is various in the various kinds of plants. Tears are liquors which are emitted from them, whether they sweat out of them naturally, or are drawn out of them, either by art, or by the heat of the sun. Some of these remain liquid; others grow by degrees into a firm consistence.

3. Plants consist of three dissimilar, solid parts, the root, the trunk, and the branches. In each of these we may observe three similar parts, the bark, the wood and the pith.

4. To begin with the TRUNK. Here we may first observe the BARK; whose surface consists of little bladders, which surround the trunk like a ring. These, which are commonly filled with some kind of juice, being removed, there occur various ranks of woody fibres, curiously wrought in a kind of net-work, one row above another. The intervals also between those fibres, are all filled with little vessels. The use of the bark seems to be, not only, like skin, to cover the wood and pith, but also to concoct the nutritive juice, and forward the growth of the plant. And as to the nutrition of the plant, it is probable the juice ascends from the root, through the fibres, and is sustained by the unevenness therein, till it is lodged in the vessels. In these the new juice being mixed, with that they contained before, is fermented, and rarified to such a degree, as is needful for its nourishment.

It has been a common opinion, that trees only live by the ascent of the sap in the bark, or between the bark and the wood. But this

evidently appears to be a vulgar error, from the instance of a large, old elm, in Magdalen College Grove at Oxford, which was quite disbarked all round, at most places two feet, at some four feet from the ground. Notwithstanding this it grew and flourished many years, as well as any tree in the grove.* What is more, it was likewise without all pith, being hollow within as a drum. Add to this, that the plane and cork-trees, divest themselves every year of all their old bark (as snakes do of their skins,) and acquire a new one. Now during the change from one to the other, it is clear they are not nourished by the bark. Therefore there must be other vessels, besides those of the bark, capable of conveying the sap. It is probable, the bark may ordinarily do this; but that when the ordinary conveyance fails, some of the woody parts, which were all sap vessels once, resume their ancient office: so far, at least, as to keep the tree alive, though not to increase its bulk. Perhaps this is the use of the sap-vessels in the wood, different from that of those in the bark. These are designed for the continuation of a tree; those in the bark for its augmentation.

It seems the bark in fruit trees is principally designed for the augmentation of the tree itself, while the finer vessels of the woody part strain and prepare the juices for the fruit. A gentleman near Cork, observing that his peach-tree grew exceedingly, but bore no fruit, cut off the bark almost quite round, for the breadth of two fingers. The next year the tree hardly grew at all, but bore abundance of fruit.

Again, as animals are furnished with the cellular membrane, which invests and covers all the fleshy parts, and screens them from external cold; so plants are encompassed with a bark, replete with fleshy juices by means whereof even the winter cold is kept off, and hindered from freezing the juices in the vessels. And those sort of trees, whose bark abounds with oil, remain green all the year round.

5. In the WOOD, likewise, there are observed concave fibers, woven as it were, of various vesicles, and stretching all the length of the wood, as do the fibres of the bark. These have intervals between them, in which are transverse, vesicles, reaching to the very pith. There are other fibres, which run obliquely, and are far larger, but not so numerous as the former. In some trees there are also several rows of tubes, which emit a thick milky liquor.

* A gentleman had an orchard of young apple trees, which promised very indifferent fruit; the two or three first years of bearing, the apples were very knotty and wormy: he was advised to strip off the bark in the proper season; he did so, and the trees after that yielded abundance of excellent fruit. Trees have been known to thrive and produce better by this method, than by grafting or innoculation.

6. The PITH is the middle of the wood. It consists of various rows of hollow globules, covered with a fine membrane. In some trees it contains a peculiar juice, which sometimes hardens, or grows black. In tender shoots the pith (which is frequently hexagonal) is not exactly in the middle; but is nearer the bark on the south side, than on the north side of the plant. It is a constant observation, that the pith lessens as the tree grows. Some have imagined it to be the heart of the plant; but this cannot be. For some trees will flourish and bear fruit after the pith is taken out. Besides this, there is in some trees a BLEA, a white and tender substance, between the bark and the wood.

7. The ROOT has nearly the same vessels as the trunk. Through it the juice passes that nourishes the plant. The roots of some plants are full of hollow threads, which transmit nourishment to the upper parts. This in other plants insinuates itself through the pores that are in the bark of the root. The branches of a plant agree with the trunk, in all the essential parts of its structure.

If no moisture comes to the roots of trees they cannot grow; but if it comes only to the points of the root, though all the rest remain dry, they grow well: for the root shoots out yearly a sharp pointed tender part, somewhat like the sharp bud on the end of a sprig, by which it not only enlarges itself in breadth, as the branches do above, but also receives its nourishment. And that tender part moves, toward the soft and moist earth. So that to loosen the earth at the points of the roots, greatly helps the growth of all plants.

8. On the smallest part of the branches grow the LEAVES: of these we may observe, 1. The fibres of the leaf stand not on the stalk in an even line, but always in an angular or circular posture: and their vascular fibres or threads, are three, five or seven. The reason of this position is, for the more erect growth, and for the greater strength of the leaf: as also for the security of its sap. 2. The accurate position of these fibres, which often take in the eighth part of a circle, as in mallows: in some plants a tenth; but in most a twelfth. 3. The art of folding up the leaves before the eruption, is incomparable both for elegance and security. They take up the least room their form will bear: and are so conveniently couched, as to be capable of receiving protection from other parts, and of giving it to each other.

Leaves consist of fibres continued from the trunk of the tree. They are clothed with an extremely thin pellicle, which is covered with the finest down. Their skin or coat is only that of the branches extended, as gold is by beating. In the bud they are folded up, almost in the manner of a fan, sometimes in two, sometimes in several plaits. But if they are too thick to plait commodiously in two, and to be ranged against each other, or if they are too small a number, or their

fibres too delicate; instead of being plaited, they are rolled up, and form either a single roll, or two rolls, which begin at each extremity of the leaf, and meet in the middle. There are also some plants, as fern in particular, which form three rolls.

The chief use of leaves seems to be, 1. To catch the dew and rain, and so convey more nourishment to the plant, than the root alone could do. 2. To take in air; (of which more hereafter;) and, 3. To minister to a kind of insensible perspiration, by which redundancies may be thrown off.

9. The nutrition of plants seems to be performed thus. As the earth abounds with particles of every sort, those which suit each plant, being dissolved by moisture and agitated by heat, enter the root through its threads or pores, ascend through the woody fibres, and being in the vesicles of the plant mixed with its native juice, and subtilized by fermentation, insinuate themselves into all parts of it. Part of this nourishes the plant and forms the fruit; the residue transpires. But as all particles are not equally fit to enter the pores of every plant, neither can all be fermented into a juice proper to nourish it: the reason is plain, why every plant will not flourish in every soil.

It is remarkable, that trees of very different kinds, draw their whole sustenance from the moisture they find in the same piece of ground, and from the ambient air and dews. Hence we may infer, that the very contexture of their bodies from the first seed, are the natural limbecs, where the common water and air are digested into so many different leaves and fruits.

We see also, that a handful of moss, sometimes above a span long, grows out of a small oyster-shell, without any earth, as do trees out of bare rocks. Hence we easily learn that the seeds first, and then the roots, stems and leaves of trees, are the strainers which secrete and generate their peculiar saps and juices. These are at first little else than pure air and water, till they are concreted in peculiar salts, by more curious strainers, and more subtile boilers than art has ever advised.

10. The ancients generally suppose the earth to produce vegetables: many of the moderns ascribe it to water alone. But it is a doubt whether the experiment was made with the nicety that is requisite. And it proves nothing, unless that water be quite pure from any terrestrial mixture; for if it be not, the plant may owe its whole growth to that terrestrial matter.

Who can find any water, newly taken out of the spring, which does not exhibit even to the naked eye, great numbers of small terrestrial particles, dispersed through every part of it? These are of two general kinds. Some are of a mineral nature, others of a vegetable.

Of the latter some are fit to nourish one plant, or one part of it, and some another. All water is much charged with vegetable matter, which is fine, light and easily moveable. Spring water contains less of it than river water, river water more than rain water.

To which of these waters, or matter sustained therein, do vegetables owe their growth? In order to decide this, the following experiments were made. Several phials of the same shape and size, were filled with equal quantities of water. Over each was tied a piece of parchment, with a hole in it just large enough for the stem, of the plant, to prevent the water from evaporating, or ascending any way but through the plant. Several plants being exactly weighed, were then placed in these phials, and as they imbibed the water, more was added from time to time. Each glass was marked with a different letter, and all set in the same window, from July 20, till October 1. Then they were taken out, the water in each phial weighed, and the plant with the leaves that had fallen off. It then appeared how much each plant had gained, and how much water had been expended upon it.

Letters on the glasses.	Weight of the plant put in.	Weight when taken out.	Weight gained in 77 days.	Expense of water.	Proportion of the increase to the expense of water.
	gr.	gr.			
A. Spear-mint set in spring-water.	27	42	15	2558	1 to 170
B. Spear-mint in rain water.	28	45	17	3004	1 to 171
C. Spear-mint in Thames water.	28	54	26	2493	1 to 95
D. Night shade in spring water.	49	106	57	3708	1 to 65

The water ascends through the vessels of plants, as through a filtre. And a larger filtre draws more water than a smaller. Therefore, plants that have more or larger vessels, draws more than those that have fewer and smaller.

But the greatest part of the water imbibed by plants, passes through their pores into the atmosphere. Hence the least proportion of water expended is to the increase of the plant, as 46 or 50 to one.—In some it is 100, 200, nay, in one 700 times as much as the increase of the plant.

Nor does this water pass off alone, but bears with it many particles of the plant. The grosser, indeed, are not so easily borne up into the

atmosphere, but are usually deposited on the surface of the flowers, leaves or other parts of the plant. Hence our honey-dews, and other gummous exudations. But the finer easily ascend into the atmosphere, and are conveyed to our organs for smell.

Great part of the terrestrial matter mixed with the water ascends into the plants. After the experiment, there was much more of it in the glasses which had no plants in them, than in those that had. Indeed, this matter being so fine and light attends water in all its motions; so that filtre it ever so often, some will remain.

The plant increases more or less, as the water it stands in, contains more or less, of this matter. So the mint in the glass C. was of much the same bulk and weight with those in A. and B. But standing in river-water, which contained more terrestrial matter than the spring or rain water wherein they stood, it increased almost double to either of them, yea, and with less expense of water.

But all vegetable matter is not proper for the nourishment of every plant. Although some parts in all may owe their supply to the same common matter, yet others require a peculiar sort of matter, and cannot be formed without it. Yea, different ingredients go to the composition of one and the same plant. If therefore, the soil wherein a plant is set, contains all, or most of those ingredients, it will grow there, otherwise not. If there be not as many sorts of particles, as are requisite for the essential parts, it will not grow at all. If they be there, but not enough of them, it will not grow to its natural stature. If the less essential particles be wanting, it will be defective in smell, taste or some other way. But though some land may not contain matter proper for some plants, yet it may for others. All this shews, that plants owe their increase, not to water only, but to a particular terrestrial matter: else there would be no need of manure, or of transplanting them from place to place. The rain falls on all places alike: on this field and that, this garden or orchard and another. Vegetables, therefore, are not formed of water. One plant drew up 2501 grains of this: yet increased only three grains and a half. The mint in B. took thirty-nine grains of water a day, which was much more than the whole weight of the original plant; and yet it gained not one fourth of a grain, in a day and night.

Water, then, is only a vehicle to the terrestrial matter, which forms vegetables. Where this is wanting, the plant does not increase, though ever so much water ascend into it. This is only the agent which conveys that matter to them, and distributes it to their several parts for their nourishment. It is fitted for this office, by the figure of its parts, which are exactly spherical; therefore easily susceptible of motion, and consequently capable of conveying other matter that is not so voluble. Beside, the constituent particles of water are abso-

lutely solid, and do not yield to the greatest external force: therefore their intervals are always alike. By this quality, water is disposed to receive matter into it: by the former, to bear it along with it.

It is farther qualified to be a vehicle of this matter, by the fineness of its particles. We scarce know a fluid in nature, except fire, whose constituent parts are so exceeding small. They pass pores which air itself cannot pass. This enables them to enter the finest vessels of plants, and to introduce the terrestrial matter to all parts of them; each of which, by means of peculiar organs, assumes the particles suitable to its own nature, letting the rest pass on through the common ducts.

11. As to the motion of the nutritive juice, some think it ascends by the wood, and descends by the bark. But it is not easy to shew, by what particular tubes it either ascends or descends. Neither after all our researches does it appear, what is the principle of this motion! Whether there be any such thing as an attractive force in the plant itself: or whether it be performed on the mere principles of mechanism, by the expansion of the air contained in the juice, which moves and propels the particles of it into every part of the plant.

However, that the sap in plants does circulate is made probable by an easy experiment. On a branch of plain jessamine, whose stem spreads into two or three branches, inoculate in autumn, a bud of the yellow striped jessamine. When the tree shoots the next summer, some of the leaves will be striped with yellow, even on the branches not inoculated. And by degrees, the whole tree will be striped, yea, the very wood of the young branches.

It is probable the circulation is performed thus: the wood of plants consists of fine, capillary tubes, which run parallel with each other from the root, and may be looked upon as arteries. On the outside of these, between the wood and the inner bark, are larger tubes, which may do the office of veins. Now the root having imbibed juice from the earth, this is put into motion by the heat. Hereby it is rarefied and caused to ascend in the form of a steam or vapour; till meeting the mouths of the arterial vessels, it passes through them to the top, and to the extreme parts of the tree with a force answerable to the heat whereby it is moved. When it arrives there, meeting with the cold of the external air, it condenses into a liquor, and in that form returns by its own weight, to the root of the venal vessels.

12. That the sap does circulate, appears farther from hence, that the graft will either corrupt or heal the stock. Nay, it changes the very way of the growing of the root, which it could not do, but by sending down its sap thither. Crab-stocks grafted with fruit, which

the soil does not like, will canker, not only in the graft, but the stock also. But graft them again with fruit it does like, and it will quickly heal. Farther: graft twenty young pear-stocks with one sort of pear, and twenty with another. The roots of one sort will grow all alike, and so will those of the other. Yet ever-green grafted on trees which drop their leaves, as the ever-green oak of Virginia upon the common English oak, hold their leaves all the winter. Does not this shew, that the juices circulate in winter, as well as summer, even in the plants which drop their leaves? Otherwise those grafted on them must soon die.

It seems that the sap does not rise by the pith: because some large trees are without that part, and yet continue to put forth branches. Indeed no pith is found in those branches of a tree, which exceed two or three years growth. And the pith which is in a branch of this year, is distributed into those boughs which are formed the next season.

Many believe, the tree does not receive its nourishment by the bark; because trees that have lost that part, continue to grow. But they suppose a tree has but one bark; whereas every branch has four distinct coverings. The two outermost of these may be taken from a tree without much damage. But if the two others be taken off, it will infallibly kill the tree.

Some affirm, that the sap neither rises nor falls in the woody part of the tree, because when a branch is cut, they cannot discern any sap issue out of it. Certainly they cannot; because those tubes are not large enough, to receive any thing more gross than vapour. The root receives chiefly in autumn its proper juices, which the warmth in spring raises into a vapour, that gradually ascends through those fine tubes, and by that means causes vegetation.

13. Some have objected to our Lord's speaking of corn increasing a hundred fold, that this is impossible. So far from it, that a grain of barley, has been known to produce two hundred and forty-nine stalks, containing about eighteen thousand grains.

A still more curious experiment was made with turnip seed, at Sutton-coldfield, in Warwickshire. In less than three days after it was sown, the turnips were above ground. In three weeks the roots were as big as walnuts; in less than five weeks, as large as apples. August 12th, one of them weighed two pounds fourteen ounces. At the same time was weighed an ounce of the seed, which had been sown, and it was found to contain fourteen thousand, six hundred single grains. This being multiplied by forty-six (the ounces that the turnip weighed) produces six hundred and seventy-one thousand, six hundred, viz. the number of single grains required to equal the weight of the turnip. Hence it follows, that (supposing the increase

was uniform) the grain when it was sown, weighing but $\frac{1}{140000}$th of an ounce, increased in the following proportions:

In six weeks	671600	Times its own weight.
A week	111933	
A day	15990	
An hour	660	
A minute	11	

In June 1766, Mr. Miller sowed some grains of common red wheat. On August 8, a plant was taken up and divided into eighteen parts. Each of these was placed separately. These plants having shot out several side shoots, by the middle of September, they were taken up and divided again. This second division produced sixty-seven plants. These remained through the winter. Another division of them made in the spring, produced five hundred plants. They were then divided no farther.

The whole number of ears, which by the process were produced from one grain, was 21109, and from calculation made by counting the whole number of grains in one ounce, might be about 576840.

14. Some plants are male and some female. Mr. Miller separated the male-plants of spinach, from the female. The seed swelled as usual, but did not grow when he sowed it. Yet it might have been impregnated another way, as appeared from another experiment. He set twelve tulips about six yards from any other, and as soon as they flowered, carefully took out the stamina. Two days after he saw bees working on other tulips, and coming out loaded with the dust. They flew into the first tulips, and left therein dust enough to impregnate them, which accordingly bore good seed. Thus we see the farina may be carried by insects, and lodged on flowers, which it is fit to impregnate.

Afterwards he bought and sowed some savoy seed, and planted out the plants, but was surprised at the production. For he had some red cabbage, some white, some savoys with red ribs, and a mixture of all together in one plant. The gardener assured him, he had carefully saved the seed. Being asked, where he had set the plants for seed, he shewed him, and said, he planted first a dozen white cabbages, next a dozen savoys, and then a dozen red cabbages. Is it not plain that here the effluvia of one sort impregnated the other? For did each grain of the farina impregnate only its own kind, this mongrel sort could never be produced.*

* The sexual character of plants may be proved by some easy experiments. Take the flowers of hemp, and pull off those of the male, before the female pistilla are fully expanded and they will not produce any fertile seeds. Another easy experiment may also be made on the tulip. Cut off all the antheræ of a red tulip before the pollen is emitted; then take the ripe antheræ of a white tulip,

An instance of the same kind has been observed with regard to Indian corn: this is of several colours, as white and red and yellow. If each of these be planted by themselves, they produce their own colour: But if you plant the blue corn in one row, and white or yellow in the next, they will interchange colours: and some of the ears in the blue corn-rows, are white or yellow, and some in the white or yellow rows, are blue. That this is caused by the effluvia of one impregnating the other, is manifest from hence: Place a close, high fence between the corn of different colours, and there is no change of colour in any of them.

The HOLLY is described by all naturalists, as bearing hermaphrodite flowers. But by late observations it has appeared, that some trees bear male, some female flowers. Yet there is a vast variety.—In Chelsea garden, some hollies bear female, some hermaphrodite flowers. But some trees bear only male flowers; some only female, some only hermaphrodite. Others bear both male and female, both male and hermaphrodite, or female and hermaphrodite. And others bear male, female, and hermaphrodite, all at the same time.

15. That the leaves of certain plants assume at night a disposition different from that of the day, is well known. This has been usually termed, the SLEEP. But to what is this owing? Not to the variation of heat or cold, moisture or dryness. For however these are varied, the same thing happens with equal regularity. It is LIGHT alone that occasions this change, which by the smallness of its particles, is capable of entering bodies, and by its activity, of producing great changes in them. It changes the position of the leaves of plants, by a motion it excites among the fibres. The natural position of the lobes in these leaves is drooping. This is their posture of repose. But vegetation is very imperfectly performed, while they remain in it. It is light which alters that position, by its quick vibrations.

and throw the pollen of the white one upon the stigma of the red; and the seeds of the red tulip, thus impregnated by one of a different complexion, will next season produce some red, some white, but mostly flowers of variegated colours. The same experiment may be tried on numerous other flowers when the pollen of the male is ripe, at the instant the pistilla of the female are fully expanded.

Thus may flowers of the most beautiful variegations be produced, by the curious florist, who is attentive to take advantage of the proper season for impregnating the female flowers. I have seen flowers of indescribable beauty produced by these means, wherein every possible colour almost has been concentred, and the substance of the flower itself augmented to double and treble dimensions, when it exhibited a noble appearance, and continued much longer in blossom than when in its primitive state. I have known the female retarded in its growth, in order to reserve it for the ripe pollen of a male flower, whose season of ripening was later than that of the female; and with good success, an equal advantage may also be taken, by planting or sowing the seeds earlier, or later, for the purpose of producing the male and female flowers in mutual season.

In the evening, August 7, (in order to make a full experiment) Dr. Hill placed a plant of abrus, in a room where it had moderate daylight, without the sun shining upon it. The lobes of the leaves were then fallen perpendicularly from the middle rib, and closed together by their under sides. Thus they continued all night. Half an hour after day break, they began to separate, and a quarter of an hour after sun-rise, were perfectly expanded. Long before sun-set they began to droop again, and towards evening were closed as at first.

Next day the plant was set where there was less light. The lobes were raised in the morning, but not so much. And they drooped earlier at evening.

The third day it was set in a south window, open to the full sun. Early in the morning the leaves had attained their horizontal situation: by nine o'clock they were raised above it, and continued so till evening. Then fell to the horizontal situation, and thence gradually to the usual state of rest.

The fourth day the plant stood in the same place, but the sun did not appear. The lobes early attained their horizontal situation, but did not rise beyond it, and in the evening closed as usual.

These experiments, prove, that the whole change is occasioned by light only. To put this beyond dispute, in the evening of the sixth day, the plant was set in a book-case, on which the morning sun shone, the doors standing open. The next day was bright. The lobes which had closed in the evening, began to open early in the morning, and by nine o'clock, they were raised in the usual manner. I then shut the doors of the book-case: on opening them an hour after, the lobes were all closed as at midnight. On opening the doors they opened again, and in twenty minutes they were fully expanded. This has since been many times repeated, and always with the same success. We can, therefore, by admitting or excluding the light, make the plant put on all its changes. Hence, we are certain, that what is called the sleep of plants, is caused by the absence of light alone, and that their various intermediate states are owing to its different degrees.*

* Light has been considered, and termed by philosophers, a property or quality of matter, rather than a substantial body. But it is now satisfactorily ascertained to be a real elementary substance, consisting of particles, inconceivably small, and like other bodies subject to the laws of attraction, and decomposition, and consequently capable of entering into the state of fixidity, and becoming an integrant part of all bodies. It is evidently concerned in electricity, and is probably the principal agent of its extreme velocity. It is an essential and powerful agent in the process of vegetation, as may be clearly inferred from the leaves of plants which commonly direct and expose their broad surface to the current of light, for the purpose of absorbing and decomposing its rays. Light becomes fixed in large proportions in carbon, hence the expansive force of gunpowder. It is observable

It has been supposed that the daily motions of the sensitive plant, were likewise owing to light and darkness; because it expands itself in the morning, and closes again in the evening. From the main branches of this plant, spring several smaller ones; and from these others, still less, which support the leaves ranged on each side, in pairs over against one another. Several other plants are of the same form, and all these close their leaves in the evening, and open them in the morning, which therefore is not peculiar to the sensitive plant. But this closes them at any time of the day, if touched, and soon after opens them again. You can scarce touch the leaf of a vigorous sensitive plant so lightly, as not to make it close. The large rib which runs along its middle, is as an hinge on which the two halves of the leaf move, when they turn upon being touched, till they stand erect, and by that means meet one another. The slightest touch gives this motion to one leaf; if a little harder, it gives the same motion to the leaf opposite. If the touch be still rougher, the whole arrangement of leaves on the same rib close in the same manner. If it be stronger still, the rib itself moves upward toward the branch on which it grows. And if the touch be yet more rough, the very branches shrink up toward the main stem. The motion which has the greatest effect of all others upon it, is the shaking one. Winds and heavy rain also cause this plant to close its leaves; but not gentle showers; the contraction being caused by the agitation of the wind, and the strokes given by the large drops.

The natural shutting and opening of its leaves at night and morning, are not so fixed, as not to be variable by many circumstances. In August, a sensitive plant was carried in a pot into a dark cave; the shaking in the carriage shut up its leaves, so that they did not open for four and twenty hours, and when they did open, they closed no more for three days and nights. Being then brought again into open air, they recovered their natural motions, shutting at night and opening in the morning, as regularly as ever. While in the cave, it was as much affected by the touch as in the open air.

By this and many experiments it appears, that it is not the light that opens these plants, nor the darkness which shuts them. Neither is it owing to the increase of heat or cold. Indeed great heat will affect them a little, but not in any considerable degree. Concerning the real cause, we may form many conjectures: but nothing certain can be known.

that the leaves and branches of trees and plants, will shoot from the shade, and direct their growth to the current of the light. Light is the essence of all colours, which occur in consequence of the absorption of particular rays, and the refraction of others. And no doubt, these circumstances concur to produce very important medical properties in plants.

Nearly related to the sleep of plants, is that which Linnæus called the awaking of flowers. The flowers of most plants, after they are once opened, continue so night and day, until they drop off, or die away. Others, which shut in the night time, open in the morning, sooner or later, according to their situation in the sun or shade, or as they are influenced by the manifest changes of the atmosphere. There are another class of flowers, which make the subject of these observations, that observe a more uniform law in this particular.

These open and shut constantly at certain hours, exclusive of any manifest changes in the atmosphere; and this with so little variation in point of time, as to render the phenomenon worth observation. Linnæus's observation extends to near fifty species which are subject to this law. We will enumerate some of these, and mention the time when the flowers open and shut. The little blue convolvulus, or bindweed, opens its flowers between five and six in the morning, and shuts them in the afternoon. The flowers of the day-lilly open about five in the morning, and shut at seven or eight in the evening. The lesser water-plantain, during its flowering-time, only opens its flowers each day about noon. The flowers of the proliferous pink, expand about eight in the morning, and close again about one in the afternoon. Purple spurrey, expands between nine and ten in the morning, and closes between two and three in the afternoon. This little plant is common among the corn in sandy soils and flowers in June. Common purslain, opens its flowers about nine or ten in the morning, and closes them again in about an hour's time. The white water-lilly grows in rivers, ponds, and ditches, and the flowers lie upon the surface of the water. At their time of expansion, which is about seven in the morning, the stalk is erected, and the flower more elevated above the surface. In this situation it continues till about four in the afternoon, when the flower sinks to the surface of the water, and closes again. Yellow goats-beard, or go-to-bed-at-noon, (the latter of these names was given to this plant long since, on account of this remarkable property) opens its flowers in general about three or four o'clock, and closes again about nine or ten in the morning. These flowers will perform their vigiliæ, if set in a phial of water, within doors, for several mornings successively. Sometimes they are quite closed, from their utmost state of expansion, in less than a quarter of an hour.

16. From what has been said it plainly appears, that there is a considerable *agreement between plants and animals*, as well with regard to their nutrition, as to the structure of their parts. Some extend this farther, and think there is something in plants answerable to respiration in animals. They suppose the spiral fibres to be in the place of lungs, and to serve this very purpose: that in each of these there

is a spiral lamina, which is extended or contracted, as it is impelled this way or that, by the elastic air it includes: that these fibres ascending straight through the trunk, are dispersed through all the branches, and thence into the leaves, where they are woven together in a kind of net work. By this means the more subtle parts of the air are strained through those spiral fibres, to keep the juices of the plant fluid, and perhaps to supply them with nitre or æther, to assist their fermentation.

The air enters vegetables various ways, by the trunk, leaves, roots and branches. For the reception as well as expulsion of it, the pores are very large in some plants. So one sort of walking canes seem full of large pin-holes, resembling the pores of the skin in the ends of our fingers. In the leaves of the pine, if viewed through a glass, they make an elegant show, standing as it were in rank and file, throughout the length of the leaves.

Air vessels are found in the leaves of all plants, and in many are visible to the naked eye; for on breaking the chief fibres of the leaf, the likeness of a fine woolly substance, or rather of curious small cobwebs, may be seen to hang at both the broken ends. Now these are the fibres of the air vessels, loosed from their spiral position, and drawn out in length.

The pores in the leaves of plants are almost innumerable. Mr. Lewenhock found above a hundred and seventy-two thousand on one side of a leaf of box. The leaves of rue are as full of holes as a honeycomb. Those of St. John's wort likewise appear full of pin-holes to the naked eye. But the places where those holes seem to be, are really covered with a thin and white membrane. Through a microscope the back side of the herb mercury, looks as if rough with silver; and all the ribs are full of white, round, transparent balls, fastened by slender stalks, like so many grapes. A sage leaf appears like a rug or shag, full of tufts of silver thrums, and embellished with round chrystal beads, fastened by tender foot stalks. The prickles of a nettle are formed for acting just as the sting of animals. Every one of them is hollow, and terminates in a fine point, with an opening near its end. At the bottom of each prickle lies a pellucid bag, containing a clear liquor, which, upon the least touching the prickles, is ejected at the little outlet, and if it enters the skin, causes pain and inflammation by the pungency of its salts.

The leaves of plants are of great consequence to their life. At these the air passes in, and goes through the whole plant, and out again at the roots. If the leaves have no air, the plant will die, as is easily proved by the air-pump: whereas if the leaves be left on the outside of the receiver, parted by a hole cemented by wax, while these have air, the plant will thrive and grow, though its roots and

stalks are kept in vacuo. The leaves likewise chiefly perform the necessary work, (but who can explain the manner!) of altering the water received at the root, into the nature of the juices of the plant. And hence it is, that the life of plants depends so immediately upon their leaves. The husbandman often suffers for the want of this knowledge. A crop of saint-foin is valuable; and its roots being perennial will yield an increase for many years. But it is often destroyed at first, by suffering it to be fed upon by sheep. For if they eat up all the leaves, the root cannot be supplied with air, and so the whole perishes. Leaves being so necessary to all perennial plants, a reversionary stock of them is provided. The leaves of these plants are always formed in autumn, though not unfolded till the following spring. They then open and increase in proportion to the motion of the sap, and the quantity of nourishment the plant receives. These leaves also, though not yet appearing out of the bud, may suffice for the extremely small motion, which the sap of those perennial plants, that drop their leaves, has in winter.

But besides these autumnal leaves, there is another set formed in spring and expanding till midsummer. These are of infinite service to many sorts of trees, particularly to the mulberry, as they save its life, when the first set of leaves have been all eaten by the silkworms.

The analogy between the parts of plants and those of animals may now more fully appear. The parts of plants are, 1. The root, composed of absorbent vessels, analogous to the lacteals in animals: indeed performing the office of all those parts of the abdomen, that minister to nutrition: 2. The wood composed of capillary tubes running parallel from the roots, although the apertures of them are commonly too minute to be seen. Through these, which are analogous to arteries, the sap ascends from the root to the top: 3. Those larger vessels, which are analogous to veins; through these it descends from the top to the root. 4. The bark, which communicates with the pith by little strings, passing between the arteries. 5. The pith, consisting of transparent globules, like the bubbles that compose froth.

The sap enters the plant in the form of pure water, and the nearer the root, the more it retains of that nature. The farther it goes, the more it partakes of the nature of the plant. In the trunk and branches it remains acid. In the buds it is more concocted. It is farther prepared in the leaves, as the blood in the lungs, which being exposed to the alternate action of heat by day, and cold by night, are alternately dilated and contracted.

Is not then the motion of the sap in plants, like that of the blood in animals, produced chiefly by the action of the air? All plants have

the two orders of vessels: 1. Those which convey the nutricious juices. 2. Air vessels, hollow tubes, within which all other vessels are contained. Now the least heat rarefies the air in these air vessels, thereby dilating them, and so causing a perpetual spring, which promotes the circulation of the juices. For, by the expansion of the air vessels, the sap vessels are pressed, and the sap continually propelled. By the same propulsion it is comminuted more and more, and so fitted to enter finer and finer vessels: while the thicker part is deposited in the lateral cells of the bark, to defend the plant from cold and other injuries.

Thus is every plant acted on by heat in the day time, especially in summer; the sap protruded, then evacuated, and then exhausted.—In the night, the air vessels being contracted by the cold, the sap vessels are relaxed, and disposed to receive fresh food for the next day's digestion. And thus plants do, as it were, eat and drink, during the night season.

The vessels themselves consist of mere earth, cemented by oil and water: which being exhausted by fire, air, or age, the plant returns to its earth. Thus in plants, burnt by the fiercest fire, the matter of the vessels is left entire: which consequently is neither water, air, salt, nor sulphur, but earth alone. The sap consists of some saline parts: others derived from air, rain, and putrified plants or animals. Consequently in plants are contained, salts, oils, water, earth: and probably all metals too. In fact, the ashes of all vegetables yield something which the load-stone attracts.

There is a considerable difference as to the time when different plants revive after the winter. No sooner does the sun begin to warm the earth, than the vernal flowers appear, and the trees, one after another, open their buds, and clothe themselves with leaves.—But why do many wood plants, as colts-foot, pilewort, violets; and many garden plants, as snow-drops, assarabacca, crocus, flower in the very beginning of spring, when we cannot by any pains or care, bring them to flower after the summer solstice? Nay, these very plants, which are so patient of cold in spring, are in the autumn so very weak and tender, that they die on the first touch of frost. Why, on the contrary, do thistles and many other plants, never flower before the summer solstice?

In the same manner, trees observe fixed laws, and a certain order in their leafing. Does the cause lie in the different depth of their roots? If so, shrubs would have leaves before trees of the same kind. But they have not. We can only say, the fact we know; but the reason of it we know not.

The order of the leafing of several trees and shrubs, observed in Norfolk, in 1755, was as follows:

1. Honey suckles, - - - - January 15.
2. Gooseberry, current, elder, - - March 11.
3. Birch, weeping-willow, - - - April 1.
4. Raspberry, bramble, - - - - 3.
5. Briar, - - - - - - 4.
6. Plum, apricot, peach, - - - - 6.
7. Filbert, sallow, alder, - - - - 7.
8. Sycamore, - - - - - 9.
9. Elm, quince, - - - - - - 10.
10. Marsh-elder, - - - - - 11.
11. Wych-elm, - - - - - - 12.
12. Horn beam, - - - - - 13.
13. Apple-tree, - - - - - - 14.
14. Abel, chesnut, - - - - - 16.
15. Willow, - - - - - - 17.
16. Oak, lime, - - - - - 18.
17. Maple, - - - - - - 19.
18. Walnut, plane, black poplar, beech, - - 21.
19. Ash, Carolina poplar, - - - - 22.

Indeed the leafing of several of these varies much, as the spring is earlier or later. But others of them, be the winter ever so mild, do not put out before their time. This also depends on some secret properties, which man is not able to explain.

17. As to the GENERATION of plants, first the tree produces buds, which afterwards expand into leaves, flowers, or branches. In the buds, entire plants are contained. A small stalk, consisting of woody and spiral fibres, springs out of the middle of the plant, wherein the bud inheres. It is involved in a thin bark, which may be divided into various leaves, lying one upon another like scales.

18. Buds are followed by leaves and flowers. In FLOWERS we may consider, 1. The calix or outer cup, designed to be a security to the other parts of the flower. Those whose leaves are firm and strong, as tulips, have no calix at all. Carnations, whose leaves are strong but slender, have a calix of one piece. Others have it consisting of several pieces, and in divers rounds. 2. The foliation or petala, the flower-leaves, which are properly the flower itself. In these, not only the admirable beauty and luxuriant colours are observable; but also their curious folding in the calix, before they are expanded.

It is remarkable, that many, if not most vegetables, especially those of a tender kind, expand their flowers, or down, every day, if it be warm, sun-shiny weather. But they close them as the evening approaches: and some, at the approach of rain. This is particularly done at the beginning of flowering, while the seed is young and ten-

der: as is easily seen in the down of dandelion, and eminently in the flower of pimpernel. These serve as a weather glass to the countryman: by the opening or shutting of these, he can tell without any danger of being deceived, whether the weather will be foul the next day.

The flower is as it were the womb, which contains the eggs or seeds of plants, and in due time brings them forth. It is near the bud, and lies hid with it during the winter, till it is brought out by the heat of the summer. The most simple plants bear a bud, which contains a seed of an oval figure. We may easily distinguish from the flower itself, the leaves of the covering which involves the bud.—From these arise the leaves of the flower, serving for the last concoction of the sap; in which are both woody and spiral fibres, with various rows of utricles. In the middle of flowers, filaments and little pillars arise, whose extremities are covered with a kind of dust. These pillars are hollow, and have vesicles full of liquor, and the rudiments of seeds, which gradually grow and harden.

That dust is of two kinds, male and female. The male dust is formed in the top of the filaments, where, when it is ripe, it bursts its case, and is split on the heads of the pillars, and thence conveyed to the utricle or matrix thereof, to impregnate the female dust contained therein.

The dust in any one plant being viewed with a microscope, every particle is of the same size and figure. But in different plants, the colour, size, and figure are widely different. In some it is clear and transparent as crystal; in others white and opaque: in some blue, purple or red, and in others, flesh-coloured. And its colour varies in the same species, suppose tulips, according to the colour of the flower.

The most general figure is the oval, more or less sharp at the ends, with one or more furrows running lengthways. But the seeds of melilot are cylinders. Those of the pansy are prisms, with four irregular sides. Others represent two crystal globules fastened together. Those of the jonquille are in the form of a kidney. But indeed varieties are not possible to be numbered. The office of the blossom is partly to protect, partly to draw nourishment to the embryo, fruit or seed. The gourd, pumpkin, melon, cucumber, and most bearing trees, have both male and female blossoms on the same plant. Male blossoms, (usually called cat-skins) may be distinguished from female, by having no pistil or rudiment of fruit about them; but only a large thrum, covered with dust in their middle. The female blossoms have always a pistil within the flower leaves; and the rudiments of the fruit are always apparent, at the bottom of the flower before it opens.

But there is a species of willow, which appears to change its sex every year. One year it produces male blossoms, and female blossoms the next.

19. The SEED, when it is ripe, is enclosed in a peculiar covering. In some plants it so increases as to become a fruit. And in these also we find fibres and utricles dispersed with endless variety.

Various are the methods which the wisdom of God takes for sowing seeds of various kinds. Those of arum and poppy are heavy enough to fall directly to the ground. Others that are light, have hooks to stop them from straying too far from their proper place. So have agrimony and goose-grass, the one wanting a warm bank, the other a hedge for its support.

On the other hand many seeds have wings, that the wind may carry them off the plant, and may scatter them asunder, that they may not fall together, and come up too thick. The kernels of pines have very short wings, just enabling them to flutter on the ground. But some seeds have many long feathers, by which they are wafted about every where.

Others are lodged in elastic cases, which dart out the seed to the convenient distances. Thus wood-sorrel, having a running root, needs to have its seed sown distant from each other. And this is done, by means of a tendinous cover, which when it begins to dry, bursts open on one side in an instant, and is violently turned inside out. The seed of harts tongue is dispersed in a different manner. It has a spring wound round its case; when it is ripe, this suddenly breaks the case in two halves, and so throws out the seed. Equally remarkable is the way wherein fern-seed is scattered. If a quantity of this be laid on a paper, the seminal vesicles burst, and are seen by a microscope projecting the seeds to a considerable distance.

The seeds of the several species of fern, were wholly unknown to the ancients. But it is now well known, that in the female fern, the whole surface of the leaf on the underside is covered with a congeries of seeds, so that they guard one another, and need no other covering. And in the common male fern, there are found at the proper season, several brown spots placed in a very regular manner. These are a fungous matter, round which the small seed vessels are inserted.

The fruitfulness of plants, in producing seeds, transcends all imagination. An elm living a hundred years, ordinarily produces thirty-three millions of seeds. Add, that if its head be cut off, it puts forth as many branches within half an inch of the place where it was cut as it had before. And at whatever height it is cut off, the effect will be the same. Hence it appears, that the whole trunk, from the ground to the rise of the branches, is full of embryo-branches, each

of which will actually spring forth, if the head be lopped off just over it. Now if these had sprung out they would have borne an equal number of seeds with those that did. These seeds therefore are already contained in them: and if so, the tree really contains 15,840,000,000 seeds, wherewith to multiply itself as many times. But what shall we say, if each seed contains another tree, containing the same number of seeds? and if we can never come, either at a seed which does not contain trees, or a tree which does not contain seed?

Timber trees of any kind, might certainly be planted to more advantage than they generally are. There is a forest two miles from St. Loe, in Normandy, planted chiefly with oaks, many of which are but of a moderate height, though of a large circumference. But near its entrance from St. Loe, there is a plantation, about twenty-five years old, wherein none of the oaks are under seventy, and some a hundred feet high. They are set so close, that they almost seem to touch one another, and are no more than four or five inches in diameter. This timber is of great use, both for making charcoal, and many other purposes. And the owners may reap four crops of them in a hundred years.

This forest belongs to the king of France, who ordered the plantation to be made by way of trial. And his ministers have caused several of these trees, a hundred feet high, to be transplanted, to leave standing proofs of the wonderful effects of the experiment.

As to sowing, the perfection of agriculture consists in setting plants at due distances, and giving a sufficient depth to the roots, that they may spread and receive due nourishment. Yet this is little regarded; but all sorts of grain are sown by handfuls cast at random. By this means four parts in five of the seed is utterly lost. To remedy this, a Spanish gentleman contrived an engine (described in the philosophical transactions, under the name of the Spanish sembrador) which being fastened to the plough, the whole business of ploughing, sowing and harrowing, is performed at once; and the grain is spread at equal distances and equally deep in the furrow. An experiment being made, land which usually produced five fold, by this means produced sixty fold. One stalk is all that springs immediately from one grain: but on the sides of this, near, if not within the ground, issue several lateral stalks. And some of these send forth roots, whence one or several other stalks spring if they are early formed, the soil good, and the weather favourable. By this means one grain of wheat planted in a garden has produced ninety, yea, a hundred ears. If then each ear, taking one with another, contains fifty grains, a single grain may produce five thousand. Nay, a gentleman in Yorkshire, who made the experiment in his garden, some years ago, counted upwards of eight thousand grains which sprung from a single one.

After all that has been said and wrote for so many centuries, on the generation or propagation of plants and animals, a late author, to whom the French naturalists in general subscribe, totally denies the whole, and censures all who pretend to discover any animalcula in the semen of animals. He will by no means allow, that every animal or plant, proceeds from an egg lodged in the parent plant or animal. On the contrary, he supposes, "there are in matter certain organical parts, disposed for the formation of animal and vegetable substances, which by coalition constitute the first stamina of all animal and vegetable bodies. These are simple, uniform, common to all, and consequently to be found more or less in every portion of the nutritive juice. From thence they are digested, and when the subject becomes adult, secreted for the formation of the seed of every plant and animal. These organical parts moving when disengaged and thence imagined to be alive, are extremely simple in their composition, being perhaps, only elastic springs, more or less compressed, more or less diversified in the direction of their force.

"All microscopic animals, so called, are indeed no other than such organical particles. Seeds macerated in water, first disunite into small particles, which soon after move and seem alive, though they are not so. The same may be observed of the juices of animals, as mutton gravy and the like. And as to the common imagination, that the male semen, while in the vessels, contains millions of animalcula like tadpoles, it is certain they are produced, after the evacuation of the fluid, and rise from principles contained therein, by a real vegetation, and a subsequent change from the vegetable to the animal life.

"Semen immediately evacuated is an homogeneous fluid. In a few minutes it begins to separate, and after this a kind of vegetable filaments grow in it, and shoot out ramifications on every side. These open and divide into moveable globules, which trail after them, something like long tails; which are in truth only strings of the viscid matter, from among which the globules were separated. By degrees the globules get rid of them, and then move at ease.

"This vegetable power of shooting into filaments, is in all animal and vegetable substances, down to the least microscopic point. And to this is really owing all that is called animal life, in the fluids produced from vegetables.

"In all our observations on these substances, the whole quantity of matter, after a separation of some volatile and saline parts, always divides into filaments, and vegetates into numberless zoophytes, which afterwards yield all the species of microscopic animals. After this those supposed animals themselves subside to the bottom of the liquor, become motionless, resolve into a gelatinous filamentous substance, and then afford new zoophytes, or animals of a smaller kind.

"Hence we may observe, that every animal or vegetable substance, advances as fast as it can, to resolve into one common principle, which is the source of all: a kind of universal semen, from which each atom may again ascend to a new life. These animalcula then in the semen of animals, and in the infusions and juices of animal and vegetable substances, are not of the nature of any other beings, nor to be ranked with them. They constitute a class apart from all others, the characteristic of which is, that they neither are generated nor subsist by nutriment, like other plants or animals, nor do they generate in the ordinary way."

What then becomes of this whole boasted branch of modern philosophy? If this be so, most of our microscopic discoveries vanish into air.

Blue flowered gentianella requires wet weather to be sown in. As soon as any rain touches the seed-vessels, they burst open and throw the seed on each side. Cardamines burst their pods and dart out their seed on a light touch of the hand: nay, the cardamine impatiens does so, even by the approach of the hand. Other seeds by their agreeable taste or smell, invite birds to feed upon them, who drop them again, fertilized by passing through their body. So mistletoe is usually sown.

The berries of mistletoe have within their viscid pulp, a kernel covered with a thin whitish skin. One placed these berries within the bark of oak, ash, beech, pear, and apple trees, by making several cuts in the sides of the trees, but the whole berries would not stay in any of them. And when he broke them, the seed always slipt out of the edge of the cut, and there stuck to the bark by its viscous covering. He stuck one seed to the bark without cutting at all, which succeeded best, and yielded two plants. The viscous matter drying away, drew the seeds close to the bark, and on these, with two more on an appletree and one on a pear-tree, there began in spring to shoot out at the end of the seed next the eye of the berry, a small deep-green shoot, like a little clasper of a vine. At first it rose upwards, then turning again, swelled out somewhat bigger round the end: yet leaving the tip quite flat, forming as it were a foot to stand upon. This foot in June came to the bark, and fixed itself thereon. Being thus fastened at both ends, it formed a little arch, whose diameter was as long as the seed. Thus it remained till March following. Then the other end let go its hold, and raising itself upward, became the head of the plant, while the end which sprung out first, became the root. It is not uncommon for the seed of ever-greens to be two years before they spring out of the ground. But this was surprising, the change of the ends, first one shooting out and then the other. Yet we find nature is uniform, and even in this strange plant, acts as in

other vegetables, first carrying the sap to form the root, then turning the course of it back again, to send out the upper part of the plant. The strangest circumstance is, that the rooting end should first shoot into the air, and then turn down to find a place to fix on. This it is, which has kept the world so long in ignorance about the growing of this seed. For by requiring a new, smooth part of the bark whereon to fix the rooting part, it has frustrated all attempts of sowing it as we do other seeds.

In strawberries and raspberries, the hairs which grow on the ripe fruit, are so many tubes leading to the several seeds. And therefore we may observe, that, in the first opening of the flower, the whole inward area is like a little wood of these hairs: and when they have received and conveyed their globules, the seeds swell and rise in a fleshy pulp.

The manner wherein mosses in general seed, is exceedingly little understood. But in one species at least, it may be clearly explained, from a number of observations. The head of this moss appears to the naked eye, smooth, and of a pale brown colour. The top of this is bounded by an orange coloured ring, which is a calix, containing sixteen pyramidal stamina, loaded with a white farina. These bend toward each other, and when the head is nearly ripe, almost meet in a point at their tops. Immediately under the arch formed by these stamina, is placed a slender, hollow pistil, through which the farina makes its way, and is dispersed among the seeds in the head. The external membrane of the head, is a continuation of the outward covering of the stalk. A section of the head shews, that this membrane includes a seed vessel so large as to fill it every way. This is filled with perfect and beautiful seeds. They are round and transparent when unripe, but afterwards they are opaque, and of a beautiful green. The number of seeds in one of these heads is not less than 13,800.

The seed vessels of mahogany trees are of a curious form. They consist of a large cone, which splitting into five parts, disclose their winged seeds. None would think, that so tall and so large trees could grow on solid rocks. They are four feet and upwards in diameter. The manner of their growth is as follows. The seeds fly along the surface of the ground, and some falling into the chinks of the rocks, strike root, then creep out upon the surface, and seek another chink. In this they swell to such a size and strength, that the rock splits and makes way for the root to sink deeper. And with this little nourishment the tree in a few years grows to that stupendous size.

The progress of germination was accurately observed by Malpighi, in the seed of a gourd. The day after it was committed to the

ground, he found the outer coat a little swelled: and in its tip a small cleft appeared, through which the sperm was seen. The second day the outward coat was much softer, the inner torn and corrupted, the germ somewhat longer and more swelled, and the beginning of the root appeared. The third day the root had made itself a passage through the coat, near the former cleft. The germ and seed-leaves also were now grown much bigger. On the sixth more of the seed-leaves had broken through, and were found thicker and harder.—The root had shot out many fibres, and the stem grown a finger's length. About the twenty-first day the plant seemed complete, from which time the seed-leaves began to droop, till they died away.

20. The parts of different FRUITS are different: but in all the essential parts of the fruit, are only continuations of the fibres, observed in the other parts of the tree. And there is a direct communication between the fruit and the remotest part of the tree. Thus an apple cut cross-ways appears to consist of four parts. 1. The skin, derived from the outer bark of the tree. 2. The pulp, which is an expansion of the inner bark. 3. Ramifications of the woody part of the tree, dispersed throughout the pulp. To these are fastened the coats of the kernels; and these being at first extended to the flower, part of them directly and part obliquely, furnish it with its nourishment. But the fruit increasing intercepts the aliment; and then the flower is starved and falls off. 4. The core, which is a production of the pith of the plant, strengthened by fibres of the wood intermixed. This is a case for the kernels, filtrates the juice of the pulp, and conveys it to them.

Fruit serve not only for the food of animals, but to guard and nourish the seed enclosed; to filtrate the coarser part of the nutricious juice, and transmit only the purest for the support and growth of the plantule.

In every sort of grain, wheat, barley or any other, there are three particulars observable: 1. The outer coat, which contains all the rest. This in the same species of grain, is of a very different thickness in different years, as also in different soils. 2. The germ or bud. This is always hid in the grain, and is the plant in miniature. And. 3. The meal, which is enclosed in the skin that surrounds the germ, and gives it nourishment, when first put into the earth, before it is capable of drawing it from the earth itself.

The whole structure of the plant which produces these grains is equally admirable. The chaffy husk is well adapted to defend the grain, as long as that is necessary, and then to let it fall. The stalk, hollow and round, is at once light and strong, capable of sustaining the ear, without absorbing too much of the juices destined for its nourishment. And the beards are a defence against the birds, that

would otherwise destroy the grain before it ripened. The covering of the grain is formed of fibres, which meet in a line and form a kind of furrow. This is the place at which the seed, when moistened, is to burst open. Were not these means prepared for the germ's coming out, the toughness of the outer coat, would have kept in both the meal and the germ, till they had rotted together.

Nor is this the only use of this place of opening. The grain is designed not only for feed, but for food also. Men have art enough to erect machines for reducing it to powder. But the birds eat it as it is, and it would pass them whole without doing them any good, were it not, that when it is moistened, it bursts open at the furrow and yields them nourishment.

The meal is composed of an infinite number of round, white, transparent bodies. These enclose the young plant, and by their figure, being easily put in motion, as soon as affected by the heat and moisture of the earth, they insinuate into the vessels of the plant, and give it increase, till it is in a condition to feed on the juices of the earth. The same process of nature is observable, when grains of corn grow out of time, on being thrown carelessly together, in a moist place.

21. Plants do likewise perspire. To find the quantity imbibed and perspired by plants, Dr. Hale took a pot with a large sunflower planted in it, and, by various experiments, found the greatest perspiration, in a very warm day, to be one pound fourteen ounces; the middle perspiration one pound four ounces. It perspired three ounces in a warm night, when there was no dew. If small dew fell, it perspired nothing; if a large dew it gained two or three ounces.

The weight of the flower was three pounds: the weight of a well sized man is one hundred and sixty. The flower perspires twenty-two ounces in twenty-four hours: the man about twenty-five; besides six ounces, which are carried off by respiration from the lungs.

A middling man eats and drinks in twenty-four hours, about four pounds ten ounces. The plant imbibed and perspired in the same time twenty-two ounces. But taking bulk for bulk, the plant imbibes seventeen times more food than the man. For, deducting five ounces for fæces, there will remain but four pounds five ounces, which enter the veins, and pass off in twenty-four hours. And since taken bulk for bulk, the plant imbibes so much more food than the man, it was necessary by giving it an extensive surface, to provide for a plentiful perspiration, since it has no other way of discharging superfluities as a man has. It was necessary likewise, that the plant should imbibe a larger quantity of fresh fluid than the man, because the fluid filtrated

through its roots does not contain so many nutritive particles, as the chyle which enters our veins.

But there is a latitude of perspiration both in men and plants. In this flower it varied from sixteen to eighteen ounces during twelve hours day, as it was watered less or more; in a healthy man it varies from a pound and a half to three pounds.

Evergreens perspire far less than other plants. In proportion, they need less nourishment: hereby they are better able to bear the winter: like insects, which as they perspire little, live the whole winter without food.

In order to try whether any sap rose in winter, he made various experiments: from all which it appeared, it does rise then also, but in small quantities. And hence we see why an evergreen grafted on an oak, will remain verdant, when the oak leaves drop. Perspiring less, it needs less nourishment than the oak, and so is sufficiently fed by the sap that rises even in winter.

In summer, when hot sunshine follows a shower, the vines in the middle of a hop ground are often scorched up, almost from one end of a large ground to the other: at the same time the vapours ascend plentifully. The scorching of the vines seems to be caused by these scorching vapours, which ascend most in the middle of the ground, the air there being more dense, and consequently hotter than on the outsides.

The white clouds likewise which appear in summer time, occasion a vehement heat, by reflecting many of the solar rays, which otherwise would not touch the earth. And if the sun be on one side, and the clouds on the other, they are perfect burning-glasses.*

Sometimes there is a kind of hollow clouds, full of hail or snow. During the continuance of these, the heat is extreme, since by such condensation they reflect more strongly. By these likewise, those blasts may be produced, as well as by the reflection of dense vapours.

The sun-flower being tender, if the sun rises clear, faces to the east. The sun continuing to shine, at noon it faces to the south, and at six in the evening to the west. The cause is, that the side of the stem which is next the sun, perspires the most, and thereby shrinks.

* These reflections from the clouds take place when the sun is in an angular position with them, but the power of reflection depends on the degrees of remoteness, and density of those clouds. The hottest weather has been known to take place, when the clouds exhibit a skirt of clear compact white, and a black and dense appearance in the centre; at a time when they were riding very low in the air. But if the clouds be elevated to a great distance from the earth, no sensible heat will be reflected from them, as their degrees of elevation, depend on the degrees of density of the atmosphere, and in proportion to this, will be the power of reflection.

What degree of heat will plants bear? The common temperate point in the thermometer is eighteen degrees. The external heat of a human body, will raise it to fifty-four degrees. Very hot sunshine will raise it to eighty-eight. Plants endure a considerably greater heat than this, near the line, for some hours a day. But the hanging of the leaves of many of them shews, they could not long subsist under it.

The winter heat is from the freezing point to ten degrees; the vernal and autumnal, from ten to twenty. The May and June heat is from seventeen to thirty, in which the generality of plants flourish best. The heat of July is, in the shade, about thirty-eight degrees; in the sunshine, at noon, about fifty. The heat of a hot-bed, when too hot for plants, is eighty-five or more: and near this is the heat of the blood in high fevers. The due heat of a hot-bed is fifty-six degrees; and the same heat hatches eggs.*

A continual steam is ascending during the summer; the sun beams giving the moisture of the earth, at two feet depth, a brisk, undulating motion, which rarefied by heat ascends in the form of vapours. And the vigour of warm and confined vapour, such as that is which is two or three feet deep in the earth, must be great, and penetrate the roots with some vigour; as we may reasonably suppose, from the vast force of confined vapour in the engine for raising water by fire.

Though vegetables have not, like animals, an engine which, by its alternate dilatations and contractions, drives their juices through them, yet has nature contrived other means, powerfully to raise the sap and keep it in motion. And their roots are covered with a very fine thick strainer, that nothing may enter but what can be readily carried off by perspiration.

That there is a lateral communication of the sap-vessels in plants, as of the blood-vessels in animals, plainly appears from the experiment of inarching trees. For when three wall-trees are thus incorporated, the root of the middlemost may be dug up, and the tree will grow still, as receiving nourishment from the trees with which it is connected. And hence elders, willows, vines and most shrubs, will grow with their tops downward in the earth. For the same reason, if you frequently, in an evening, wash the bodies of new planted trees, they will grow quicker and better than any others of the same plantation.

* Different plants delight in different degrees of heat, hence some are later in the season than others, but no plants will thrive at the freezing point, which is 32 degrees of Fahrenheit's thermometer. The observations in the text appear to be adapted to a different thermometer, as the due heat for hatching eggs is 108° and that of a high fever 112° of Fahrenheit.

22. If the top of a VIBURNUM is planted in the ground, it becomes roots, and the roots turned up become branches; and the plant grows exactly as well as it did in its natural position, whether the vessels which fed the branches have changed their course, or whether the juices go up and down the same vessels.

23. I cannot better conclude this chapter, than by tracing the analogy between the propagation of animals and that of vegetables. The roes of fishes, the eggs of insects, birds, and all other animals nearly resemble each other. They are compact bodies of such forms as best suit their natures. They all have integuments, nobly contrived for their preservation, with firm coverings to secure them from outward injuries. Those to be kept in the body have coverings also; but soft and membranous. Every kind contains its peculiar substance, differing from that of every other kind. And all these characters belong also to seeds of every kind. They have their coverings, more or less compact, according to their necessities. Their forms are convenient. The substances they contain are specifically different from each other: and their offspring proceeds from them in the same manner, as animals proceed from their eggs.

But beside the substances peculiar to each seed, there is a peculiar organization treasured up in each, which is the rudiment of the future plant, capable of being propagated into such a plant as it sprung from, and no other. So in every one of the nut-kind, there is a visible organization, peculiar to each species. And if such an organization appears in every seed, which is large enough to be viewed clearly, we cannot reasonably doubt of their existence, even in those which are so small as to escape our sight. There are multitudes of seeds, which produce large plants, and yet appear only like dust, and a vast number, which we cannot see but by the microscope. And yet these doubtless have all their peculiar forms, and their organizations as well as the larger.

But from what are these organizations produced? How does every plant or animal bring forth a fresh one after its kind? A little of this we may understand, if we trace a tree and an animal through every stage from the egg to their utmost growth.

See a young tree pushing out its leaves and flowers, till it has extruded an entire set of boughs and branches. One part regularly opens after another from the first shoot till it comes to perfection. Then, and not before, it produces seeds, containing the rudiments of other trees like itself. The fibres of its general organization grow into little knots, some to form leaves, some the calix, some the petals, some the pistil and utricle, some again the little seeds, each growing from its own pedicle. For the male parts, other fibres are formed into stamina, and from these terminate into apices: and again from

these others terminate into the minute grains, commonly called the farina fæcundans ; each grain growing on its own pedicle, just as the leaves or fruits of trees.

See an animal, exactly in the same manner, unfolding itself by degrees, till its parts are explicated entirely, and it is complete in every organ. Then, and not before, each female is capable of producing eggs, each being a continuation of the general organization, and growing upon its own pedicle. Each male, likewise, when at its state of perfection, is capable of producing from itself the fecundating matter, necessary for the propagation of the species.

Let us again view a full grown tree or plant, putting forth its parts for fructification. Observe the apices on the stamina, loaded with the globules of the farina fæcundans, the pulp of each globule containing an exalted fluid, and conveying it to one of the papillæ of the pistil. The utricle is now filled with green, soft seeds, ready to be impregnated by the globule, and containing a fluid, which afterward becomes a hard covering to each. And within this the little organization gradually increases.

As then a refined fluid from the seminal matter of the male, impregnates the organization in the egg of a female animal, mingles with the subtle fluids contained therein, and promotes its growth and progress : so the refined part of the pulpy fluid contained in the globule, impregnates the organization in the seed of a plant, mixes with its juices, and gradually promotes its growth into a perfect plant. And doubtless both the impregnating effluvia of animals and vegetables, and the innate juices of the organization, have qualities peculiar to themselves. Hence the offspring of a black and a white parent, is of a colour between both. And thus if the farina of one sort of flower impregnate the egg of another, the colour of the flower produced thereby is variegated proportionably.

The juices imbibed by a plant, becoming composed of innumerable various substances, after every part has attracted its kindred particles, the superfluous ones are carried off by perspiration ; chiefly by the leaves, which are the emunctories, that throw off those juices which have no kindred particles in the plant. Accordingly, when the warm sun begins to rarefy the fluids, which during the winter were condensed and inactive, the new leaves then begin to put forth, from their several organizations. When winter comes, as no more fluids ascend in trees, so there is no perspiration. Consequently most of them need leaves no longer, which therefore fall off. Nor are they succeeded by others, till the vegetable begins to receive fresh nourishment, and has occasion therefore for excretory vessels to carry off superfluities. Just so the superfluous juices, in animals, are con-

tinually carried off by perspiration: an obstruction of which is equally pernicious to animals and vegetables.

But is there any thing in the vegetable kingdom analogous to that strange animal the polypus, which multiplies by being cut in pieces? There is. View, for instance a young willow. This is an organized body, capable of growing, till it comes to its perfect growth by means of the vegetative principle. The polypus is an organized body, capable of being extended till it comes to its perfect growth, and of feeding and loco-motion, by its animating principle. The willow as it grows, is gradually sending off new branches, which are its fœtuses, proceeding from the organizations lodged in every part. The polypus, in like manner, gradually sends off new fœtuses, from organizations placed in every part of it. If the willow be cut in pieces and planted, each piece will be explicated into a tree, and then send forth new fœtuses, like its parent. And if the polypus be cut in pieces, each piece will be explicated into a polypus, and then extrude new fœtuses: so that cutting it in pieces, is but anticipating the propagation of those organizations in the pieces, which would, if let alone for awhile, themselves issue from the sides of the parent.

If we observe the extreme tenderness of this animal, liable to be wounded, nay torn in pieces, by any hard body, which is carried down the streams, or moved in the ponds, wherein they dwell: we see the Providential reason for this contrivance to propagate them: as perhaps no other animal is of so tender a texture, and so easily destroyed, having neither sagacity to avoid danger, nor strength to bear the least violence.

Other trees have been propagated by a still more surprising way. One having caused some ashen pipes, that had brought water to his fountain twelve years, to be taken up, they were left in the yard, where they rotted almost entirely. But in their room there shot up a young forest of ashes, which are now about four feet high. There is no ash-tree within a great distance of the yard. Where then were the seeds from which they sprung?

24. Mr. Bonnet, of Geneva, was inclined to try whether plants would grow, when planted in moss instead of earth. So he filled several garden-pots with moss, and compressed it more or less, as he judged the several plants might require a closer or a looser soil.

He then sowed therein wheat, barley, oats, and peas. And he found, 1. That all the grains thus sown, came to maturity later than those of the same sorts, which had been sown in mould. 2. That the stems from the seeds sown in moss, were generally taller than those sown in earth. 3. That there came more blades from the grains sown in moss, than from those sown in the ground. 4. The grains

sown in moss produced more plentifully than the others. 5. The grains gathered from the wheat which grew in the moss, having been sown again, partly in moss and partly in earth, succeeded well in both.

He also planted in moss, pinks, daisies, tulips, jonquilles, and several other sorts of flowers. And all these succeeded full as well, as those of the same sort which he planted in mould. He also placed in moss, cuttings and layers of vines, all which grew up into vines. And these in a while were larger than those which came from cuttings and layers planted at the same time in the ground.

Mr. Kraft sowed oats and hemp-seed in rich earth, in sand thoroughly dried, in shreds of paper, in pieces of woollen cloth, in chopt hay. He afterwards watered them daily, and they grew nearly as well in one substance as in another.

The husbandry of figs, as it is still practised in many parts, is one of the greatest curiosities in nature. There are two sorts of fig trees, the wild and the garden fig tree. The wild bear three kinds of fruit, fornites, cratitires, and orni: and all these are necessary to ripen the garden fig. The fornites appear in August, and hold to November without ripening. Herein breed small worms, which turn to a kind of gnats, no where to be seen but about these trees. In November these gnats make a puncture in the cratitires, which do not appear till towards the end of September, and the fornites gradually fall off, after the gnats have left them. The cratitires remain on the tree till May, and enclose the eggs deposited in them. In May the orni appear, which, after they grow to a certain size, are pricked by the gnat issuing from the cratitires.

None of these are good to eat, but only to ripen the fruit of the garden fig tree in the following manner: In June and July, the peasants take the orni, when their gnats are just ready to break out, and carry them to the garden fig tree. If they do not mind the time exactly, the orni drop, and the garden fruit not ripening, for want of its proper puncture, will likewise fall soon after. Therefore they carefully inspect the orni every morning, and transfer such of them as are proper. By this means the garden figs become ripe, in about six weeks after they have received the puncture of the insect. When they have dried them in the sun, they put them into ovens, to destroy the eggs of the gnats laid in them, from whence otherwise worms would be produced, which would consume the fruit.

What an expence of time and pains is here! Who can but admire the patience of the Greeks, busied above two months in carrying these prickers from one tree to another! But how do these contribute to the ripening of the garden figs? Perhaps by causing the nutricious juice to extravasate, whose vessels they tear asunder in depo-

siting their eggs. Perhaps too they leave with their eggs some kind of liquor, proper to ferment with the milk of the fig, and make it tender. Figs in Paris ripen sooner, for having their buds pricked with a straw dipped in oil.

CHAPTER II.

1. IT remains to give a short account of some remarkable productions of the vegetable kind.

The grass of the submarine meadows is not a span long, and is of a green approaching to a yellow colour. The tortoises seem to live wholly on this: but they bite much more of it than they swallow. Hence the sea is covered with this grass, wherever they feed at the bottom. About once in half an hour they come up, fetch one breath like a sigh, and sink again. They breathe somewhat oftener when on shore: if you hurt them, the tears will trickle from their eyes. They will live out of water twenty days and be fat, if they have twice a day half a pint of salt water.

A submarine sensitive plant has been observed on the Irish coast. It consists of a long slender tube about as thick as the barrel of a goose quill, growing about six or eight inches out of the crevices of the rocks, especially in such hollows as the salt-water remains in, after the tide ebbs away. In the middle of the tube springs up a slender stalk. The top of which is a reddish, round vesicle. If you point a finger to this, as soon as you are near touching it, the stalk withdraws to the very bottom of the tube, and the tube itself bends and becomes flaccid. The plant has no branches, nor can the root be separated from the rock without breaking it. On the Cornish shores, there grows a kind of a sensitive fucus. Bring this so near the fire as just to warm, and its edges shrink up. In this state, move a finger toward them, and they shrink from it, but if the finger is removed, recover their former situation. Placed on a warm hand, it moves perpetually to and from the hand, like an animal struggling for life. It seems this odd effect is owing to the structure of these plants. They are so extremely thin that they yield to the perspiration of the hand; the effluvia being of force sufficient to repel the leaves when they are near.

The vines of hops wind about the poles with the sun, those of kidney-beans against the sun, and that so obstinately, that although the one or the other be over-night wound the opposite way, yet in the morning it will be found to be got back again to its natural bent.

The herb of Paraguay, as it is called, is the leaf of a tree, of the size of a middling apple-tree. It is sent to Peru and Spain, in great quantities, well dried and almost reduced to powder, being used by the miners and many others, as we use wine, and the Turks opium, to raise the spirits. Indeed the Spaniards believe it to be a preservation from, and remedy for, all their disorders. It is opening and diuretic, and what is surprising, produces very different effects at different times. It purges some, and nourishes others: it gives sleep to the restless and spirits to the drowsy. Those who are accustomed to the use of this herb, can scarce ever leave it off, or even take it moderately; though when used to excess, it brings on most of those disorders that attend the too free use of strong liquors. They prepare it nearly as we do tea; but seldom use any sugar with it. Sometimes they take it by way of a vomit: then they drink it lukewarm.

The caa-tree (that is its proper name) thrives best in the marshy bottoms between the mountains of Maracayu, east of Paraguay, in about twenty-five degrees twenty five minutes south latitude. They sometimes send to Peru alone, in a year, a hundred thousand arobes, (an arobe is 28 pounds,) and each arobe is worth seven French crowns.

By the whole account, this appears to be a species of tea, little differing from some of those which grow in China. The leaf is a third part less than that of bohea-tea, but much hardier: for it bears the English frost, which that will not. Bohea-tea has a smaller and a darker leaf than green; which is as large and as bright as a bay-leaf, and endures all weathers. All these appear to be of a laurel kind, and I doubt, if laurel, or bay-leaves properly cured, would not equal any of them.

The coco-tree grows straight, without any branches, thirty or forty feet high. Near the top it bears twelve leaves, each ten feet long, and half a foot broad. These are used in making mats, covering houses, and for many other purposes. Above the leaves grows a large excrescence, in the form of a cabbage. But the taking it off kills the tree. Between the leaves and the top grow several shoots, as thick as a man's arm, which when cut, yield a white, sweet, agreeable liquor, serving as wine, and equally intoxicating. Yet at the end of four-and-twenty hours, it becomes a strong vinegar. As long as this liquor distils, the tree bears no fruit; but when these shoots are suffered to grow, it puts forth a large bunch, wherein the coco-nuts are, to the number of ten or twelve. In each there is about half a pint of clear cooling water. In a little while this becomes a white, soft pulp, which afterwards condenses into a nut. The tree yields fruit thrice a year. Some of the nuts are as large a man's head.

The cacao-tree is of a middling size: the wood is porous, the bark is smooth, and of a cinnamon colour. The flower grows in bunches between the stalks and the wood, of the form of roses, but without scent. The fruit containing the cacao is a sort of pod, of the size and shape of a cucumber. Within this is a pleasant, acid pulp, which fills up the interstices of the nuts till they are ripe. Then they lie close together, in a regular and elegant order. They have a tough shell; within which is the oily substance, whereof the chocolate is made. This fruit grows differently from our European fruits, which always hang upon the small branches: whereas this grows along the body of the great ones, principally at the joints. None are found on the small; a manner of vegetation strange here; but which prevails in several other plants within the tropics.

The tallow-tree, which grows plentifully in China, is about the height of a cherry-tree. Its bark is very smooth, and its leaves of a deep shining red. Its fruit grows in a pod, like a chesnut, consisting of three white grains: each of which is about the size, and of the form of a small nut. In each is a little stone, surrounded with a white pulp, in consistence, colour, and even smell, like tallow. And this it is, of which the Chinese in general make their candles.

The horse-chesnut contains a saponaceous juice, useful not only in bleaching, but also in washing linens and stuffs. Peel and grind them; then the meal of twenty nuts, is sufficient for ten or twenty quarts of water. Either linen or woollen may be washed in the infusion, without any other soap. It takes out spots of all kinds, rinsing the clothes afterwards in spring water.

If you grind the nut, steep the meal in hot water, and then mix it with an equal quantity of bran, both hogs and poultry will eat it. Both horses and cows will eat the nut itself, mixed with other food.

The sago-tree is between twenty and thirty feet high, and about five or six round; it grows in the Molucca islands. Its outward bark is about an inch thick: under this are ligneous fibres, which cover a mass of a kind of gummy meal. When this is ripe, a whitish dust transpires through the leaves. The Malais then cut down the tree, scoop out the mealy substance, dilate it with water, and strain it through a fine cloth. It afterwards gradually dries and hardens, and will keep good for many years.

Palm-trees are male and female. In March or April, when the sheaths that enclose the young clusters of the flowers and fruit begin to open, at which time the dates are formed, they take a sprig of the male cluster, and insert it into the sheath of the female; or else take a whole cluster of the male tree, and sprinkle the farina of it over several clusters of the female. Where they use the former method, one male suffices to impregnate four or five hundred females.

The palm-tree is in its greatest vigour about thirty years after transplantation, and for seventy years longer bears, yearly, fifteen or twenty clusters of dates, each of fifteen or twenty pounds weight. Afterward they gradually pine away, and usually fall about the latter end of their second century.

To procure the honey of the palm-tree, they cut off its head, and scoop the top of the trunk into the shape of a basin. The sap ascending lodges in this cavity, for the first ten or twelve days, three quarts or a gallon a day. Then it gradually diminishes, till in six or eight weeks, the juices are consumed, and the tree is fit only for firewood. This liquor is a thin syrup, of a more luscious sweetness than honey. Hence our poet mentions,

> "Fruit of palm tree, pleasant to our thirst
> And hunger both."

Though one would imagine, a liquor of that kind, would not be very proper to quench thirst.

I find, of the number of Sicilian plants, says a late writer, the cinnamon, sarsaparilla, sassafras, rhubarb, and many others commonly thought not to be natives of Europe. The Palma Christi too, that plant so much celebrated of late, from the seed of which the castor oil is made, grows in many places of Sicily in the greatest abundance. Our botanists have called it *ricinus Americanus*, supposing it only to be produced in that part of the world.

But the most uncommon of all the vegetable productions of Sicily, are some of the trees that grow on the sides of Mount Ætna. Three of these are nearly of one size; but one is rather taller than the other two. It rises from one solid stem to a considerable height; after which it branches out. I measured it about two feet from the ground, and found it seventy-six feet round. All these grow on a thick, rich soil, formed originally of ashes, thrown out by the mountain.

The balsam-tree grows on rocks, and frequently on the limbs or trunks of other trees. This is occasioned by birds scattering or voiding the seeds, which being glutinous, like those of mistletoe, take root and grow: but not finding sufficient nourishment, the roots spread on the bark till they find a decayed hole wherein is some soil. Into this they enter and become a tree. But the nourishment of this second spot being exhausted, one or two of the roots pass out of the hole, and fall directly to the ground, though at forty feet distance. Here again they take root, and become a much larger tree than before. They flourish on the Bahama islands, and many other of the hot parts of America.

In Italy are many coppice woods, of what our gardeners call the flowering ash. Manna is procured by piercing the bark, and catching

the sap, as we do that of birch trees, to make birch wine. It begins to run in the beginning of August, and in a dry season, runs for five or six weeks. The leaves of this tree are the proper senna, and better than any brought from Apulia.

Peruvian bark comes from a tree, about the bigness of a plum tree. Its leaves are like ivy, and are always green. It is gathered in autumn, the rind is taken off all around, both from the boughs and the tree, and grows again in four months. It bears a fruit, not unlike a chesnut, except its outward shell. This shell is properly called China-China, and is esteemed by the natives, far above the bark, which is taken from the trunk or boughs. And it seems this only was in use, till the demand for it so increased.

The tree which produces cotton, is common in several parts both of the East and West-Indies. The fruit is oval, about the size of a nut. As it ripens, the outside grows black, till opening in several places by the heat of the sun, it discovers the cotton, of an admirable whiteness.*

Pepper grows on a shrub in several parts of the East-Indies, which is of the reptile kind; and for that reason is usually planted at the foot of some larger tree. It grows in clusters, which at first are green. As the grains ripen, they grow reddish; and after being exposed awhile to the sun, become black. To make white pepper, they moisten it with sea water, and then exposing it to the sun, divest the grains of the outer bark, which of consequence leaves them white.

The tree that bears Jamaica pepper, is about thirty feet high, and covered with a gray, smooth, shining bark. It shoots out abundance of branches, which bears large leaves, like those of the bay tree. At the very end of the twigs grow bunches of flowers, each stalk bearing a flower which bends back. To these succeeds a bunch of berries, larger when ripe than juniper berries. They are then black, smooth and shining: but they are taken from the tree when unripe, and dried in the sun. They have a mixed flavour of many kinds of spice, and hence they are called all-spice.

The plant which affords ginger, resembles our reed, both in its stem and leaves. The root spreads itself near the surface of the ground, in form not unlike a man's hand. When it is ripe they dig it up, and dry it either in the sun, or in an oven.

* The use of cotton in medicine, has not been much investigated; it has long been considered as pernicious to the flesh, on account of its eating nature, but it has been found of most excellent use, applied to fresh burns and scalds. I witnessed a surprising instance of its peculiar efficacy some time ago, in the case of a very bad burn; the raw cotton was spread pretty thick over the parts that were burnt, and very soon the anguish subsided, and to the astonishment of every person acquainted with the case, the patient was very soon restored to a sound skin.

Nutmegs are enclosed in four different covers; the first, thick and fleshy, like that of our walnuts: the second is a thin, reddish coat, of an agreeable smell, called mace. The third is a hard blackish shell. The fourth is a greenish film. In this the nutmeg is found, which is properly the kernel of the fruit.

The WILD PINE, as it is called, is a wonderful instance of the wise providence of God. The leaves of it are channelled, to catch and convey water into their reservoirs. These reservoirs are so made, as to contain much water. And they close at the top when they are full, to hinder its evaporation. These plants grow on the arms of the trees in the woods, as also on the bark of their trunks. Another contrivance of nature in this vegetable is very admirable. The seed has many long and fine threads, that it may be carried every where by the wind, and that by these, when driven through the boughs, it may be held fast, and stick to the arms or trunks of trees. As soon as it sprouts, although it be on the under part of a bough, its leaves and stalk rise perpendicular, because if it had any other position, the cistern made of hollow leaves could not hold water. In scarcity of water, this reservoir is not only necessary and sufficient for the plant itself, but likewise useful to men, birds and insects. Hither they then come in troops, and seldom go away without refreshment.

These leaves will hold a pint and a half, or a quart of rain-water. "When we find these pines," says Captain Dampier, "we stick our knives into the leaves, just above the root; and that lets out the water, which we catch in our hats, to our great relief."

The same Providential design is answered by the WATER-WITHY of Jamaica. This, which is a kind of vine, grows on dry hills in the woods, where no water is to be found. Its trunk, if cut into pieces, two or three yards long, and held by either end to the mouth, affords a limpid, innocent and refreshing sap, as clear as water: and that in so great abundance, as gives new life to the weary and thirsty traveller.

An admirable instance of the same good Providence we have in the FOUNTAIN tree, which grows on Hierro, one of the Canary Islands. In the rocky cliff which surrounds the island, is a narrow gutter, which begins at the sea, and continues to the summit of the cliff, where it falls into a valley, which is bounded by the steep front of a rock. On the top of this grows a tree, which has continued many years. Its leaves constantly distil as much water as is sufficient for the drink of every living creature on the island. It stands by itself a league and a half from the sea, and no one knows of what species it is. Its trunk is about nine feet round, in diameter about three. It is thirty feet high; the circumference of all the branches together is about ninety. The branches are thick, the lowest of them is about

an ell from the ground. Its fruit resembles an acorn, its leaves resemble those of the laurel, but are longer and broader. They come forth in perpetual succession, so that the tree is always green. On the north side of it are two cisterns of rough stone, each fifteen feet square, and twelve deep; one of which contains water, for the drink of the inhabitants; the other, for their cattle and all other purposes.

Every morning, near this part of the island, a mist rises from the sea. This the south and the easterly winds drive against the forementioned cliff, which it gradually ascends, and thence advances to the end of the valley. Being stopt there by the front of the rock, it rests upon the leaves and branches of the tree, whence it distils the remainder of the day.

But trees yielding water are not peculiar to the island of Hierro. One of the same kind grows on the island of St. Thomas, in the gulf of Guinea. And of the same nature is that near the mountains of Vera Pogz, whereof we have the following account in Cockburne's Voyages.

"In the morning of the fourth day, we came out on a large plain, in the midst of which stood a tree of an unusual size. Its trunk was above five fathoms round: the soil it grew on was very stony. And on the nicest inquiry we could afterwards make, both of the Spaniards and the natives, we could not learn, that any other such tree had been known in all New Spain.

"Perceiving the ground under it wet, we were surprised, knowing that according to the certain course of the season in that latitude, there had no rain fallen for six months, and that it could not be owing to the dew, for this the sun entirely dried up, in a few minutes after its rising. At last, to our great amazement, as well as joy, we perceived water dropping from the end of every leaf; after we had been labouring four days through extreme heat, and were almost expiring for thirst, we could not look upon this, but as liquor sent from Heaven, to relieve us in our extremity. We catched it in our hands, and drank so plentifully, that we could scarce tell when to give over."

The MANCHINEEL APPLE is most beautiful to the eye, agreeable to the smell, and pleasant to the taste, but the whole tree is so poisonous, that the wood of it while green, if rubbed against the hand, will raise blisters.

The wood is good for tables, cabinets, and all other curious work. But the virulent nature of the sap, calls for great caution in felling the tree. I was cutting down one of them, says Mr. Catesby, when some of the milky juice spurting in my eyes, I was two days totally blind, my eyes and face being much swelled. For four-and-twenty hours, I felt a violent prickling pain, which then gradually abated.

Indeed, it is reported, and generally believed, of this tree, that the wound of an arrow dipped in its juice is mortal; that the rain which washes the leaves, will raise blisters on the skin; and that even its shadow is so noxious, that the bodies of those that sleep under it swell. Yet a pregnant woman ate three of the apples without any inconvenience: and a robust man of about forty-five years of age, ate more than two dozen without being disordered more than twenty-four hours. About an hour after he had eaten them his belly swelled, and he complained of a burning heat in his bowels. He could not keep his body in an erect posture; his lips were ulcerated, and he was seized with cold sweats; but he was relieved from all these symptoms by a decoction of the leaves of *ricinus* the *avellana purgatrix*, in water, which being drank plentifully, produced a violent vomiting and purging, for four hours; after this he was made to walk about, and some rice gruel perfected the cure.

The negroes in Africa use a poison of an extraordinary nature. The dose is very small, and hath no ill taste. The symptoms are various, according as the dose is. It kills sometimes in a few hours, sometimes in months; at others, in some years. If a great quantity is given, death follows in six or seven hours. (The negroes turn white.) If the dose is but small, the sick looses his appetite, feels pain in his head, arms, and limbs, a weariness all over, soreness in his breast, difficulty in breathing, and at last dies languishing. Probably it is the same poison which is used in Spain and Italy. This hath but one specific antidote, the knowledge of which a famous negro-poisoner, was at length persuaded to impart. The antidote is the root of the sensitive plant. Take none of the root but what is in the ground; wash it well, and split it in two. Take a good handful of these split roots; steep them in three quarts of fair water, in an earthen glazed pot, having a cover. Use but a moderate fire, that it may boil gently. The decoction has no ill taste: you may add sugar, as you think best. Give the patient a good glass of this decoction as warm as he can drink it; an hour after give another, and so for some time, till you make a perfect cure. There is no danger of giving too much, it can do no harm at all.

In the valley of the Lancy, which runs between the mountains of Juria, grows a plant like the dorinicum, near the roots whereof is found pure quicksilver, running in small grains like pearls. One would not imagine the plant had any influence on this, but for the following experiment. Express the juice: expose it to the air in a clear night, and there will be found as much mercury as there is lost of juice.

But of all productions of the vegetable kind, there is none more remarkable than the aloe. It grows exceeding slowly. But the slow

ness of its growth is afterwards compensated by the bulk to which it arrives, the velocity with which it shoots, and the prodigious number of flowers it produces, which ordinarily amount to several thousands. It usually takes up three months, May, June, and July, from the first budding of the stem, to the finishing of the flowers. There are however exceptions to this rule. The aloe in the garden of cardinal Farnese at Rome, shot up in the space of one mouth, to the height of twenty-three feet. Another at Madrid grew ten feet in one night, and twenty-five more in the night following.

The progress of the Venetian aloe, in the garden of the signior Papatava, was as follows: It began to shoot its stem on the 20th of May, which by the 19th of June, was risen four Paduan feet and an inch. On the 24th it had gained ten inches more, and on the 29th eight more, on which day it began to emit branches. On the 6th of July it had gained one foot one inch: on the 17th one foot eight inches more; on the 7th of August one foot and a half. From that day to the 30th, it grew very slowly, but continued emitting branches and flowers. The trunk was at the bottom a foot thick; the branches were twenty-three in number. On the top of each was a knot or collection of flowers. On each of the first branches there were an hundred and twelve: on others a hundred and ten, and on others a hundred. They yielded little smell: but what was of it was agreeable.

When the tree has once flowered, it quickly dies, being quite exhausted by so copious a birth. They seldom flower till they are of a considerable age, when they are of a large size and a great height. As soon as the flower stem begins to shoot from the middle of the plant, it draws all the nourishment from the leaves, so that as that advances, these decay. And when the flowers are fully blown, scarce any of the leaves remain alive. But whenever this happens, the old root sends forth a numerous quantity of offsets for increase.

Perhaps there is scarce any plant in the creation which is of so general use. The wood of it is firm, and serves for fences, and for the use of the carpenter. The leaves make coverings for houses: the strings and fibres serve, in the room of hemp, flax and cotton. Of the prickles are made nails and awls, as also pins and needles. And from a large aloe, when rightly tapped, may be drawn three or four hundred gallons of juice, which by distillation grows sweeter and thicker till it becomes sugar.*

* The aloe is a kind of symbol used by the Mahometans in their religion. Every one on returning from a pilgrimage to Mecca hangs it over his street door as a token of his having performed that holy journey. They also consider it as possessed of supernatural virtues, and capable of preventing evil spirits and appa-

If there be a more beautiful flower than that of the aloe, it grows on a species of CEREUS (or prickly pear, as they call it in America,) which grows well in our stoves: about the middle of July the flower is grown to its bigness. Till then it appears like a bit of wool on a dead stem. It usually begins to open about five in the evening, is full blown about eight, and continues so till about four the next morning. It then gradually closes, and is shut up about six o'clock, covered with a cold moisture. The calyx or empalement is a foot in diameter, divided into sixty segments; the outside of a fine gold colour, the inside of a splendid yellow, spreading like the rays of a star. The petals are about thirty, in form of a cup, of a pure white. There is one style surrounded by a great number of stamina. It sends forth a very fragrant perfume, like the gum Benjamin while in blossom; the empalement and petals open one by one with great elasticity.

There is not in nature any flower of greater beauty, or that makes a more magnificent appearance. What pity, that it is only an ephemeron! Literally the creature of a day!

It has been before observed, that as all animals are from eggs, so all vegetables are from seeds. But many have supposed there is one sort of vegetable, which is an exception to this; namely, mushrooms: the seeds whereof have been long sought in vain. And it is certain, if you only range in April, balls of horse dung, as big as one's fist, in lines three feet distant from each other, and one foot under ground, covering them all over with mould, and that again with horse dung, in the beginning of August the upper pieces of dung will begin to grow white: being covered with fine white threads, woven about the straws whereof the dung is composed. By degrees the extremities of these threads grow round into a kind of a button: which enlarging itself by little and little, at length forms itself into a mushroom. At the foot of each, when at its full growth, is an infinity of little ones. The white threads of the dung preserve themselves a long time without rotting, if kept dry. And if they are laid again in the ground, they will produce new mushrooms.

ritions, from entering their houses: on this account whoever walks the streets of Cairo, will find it suspended over the doors both of Christians and Jews.

There is a species of the aloe called the Meguei, in Mexico, which yields almost all the necessaries of life. It serves for fences for their fields, its trunk yields the timbers for their houses, and its leaves serve instead of tiles. From it they make paper, needles, thread, clothing, shoes, stockings, cordage, wine, honey, sugar, and vinegar. Of the trunk and thickest part of the leaves, when well baked, they make a tolerable dish of food. And from it also the apothecary furnishes his shop with all the needful medicines. It is consequently a tree highly valued, and of immense profit to the Spaniards.

"Are these then any thing else than the mouldiness or putrefaction of horse dung?" Yes, certainly. Indeed all mouldiness, so called, is a congeries of very small plants. And these in particular, like other plants, have their origin from seeds. But before the seeds can vegetate, there are required, certain juices, proper to penetrate their coats, to excite a fermentation in them, and to nourish the minute parts thereof. Hence arises that vast diversity of places, wherein different sorts of this plant are produced. Some will only grow on other particular plants, whose trunk or roots have the juices proper for them. Nay, there is one sort which grows only on the fillets and bandages of the patients, in the hospital at Paris. It is not therefore at all surprising that horse dung should be a fit soil for common mushrooms. It is probable the seeds of these are spread in numberless places, well nigh throughout the whole earth. And the same may be said concerning the seeds of many plants, as well as the eggs of many insects: more especially of those which are so minute, that we can scarce discern them even with glasses: seeing the smaller they are, the more easily may the least wind convey them hither and thither. So that in truth the earth is full of an inconceivable number both of animals and vegetables, perfectly formed in all their parts, and designed as it were in miniature; only waiting for certain favourable circumstances to enable them to make their appearance at large."* How rich then must that hand be, which hath sown them with so much profusion.

It may not be improper, before concluding this head, to describe one more species, of sea plants. Coral grows chiefly in grottoes, which open to the south, and whose concave arch is nearly parallel to the surface of the earth. It will not grow at all, but where the sea is quiet as a pond. It vegetates the contrary way to all other plants; its root adhering to the top of the grotto, and its branches shooting downward. The root takes the exact form of the solid it grows to, and covers it, as far as it goes, like a plate; and this is a probable proof, that its substance was originally fluid. Accordingly corals sometimes line the inside of a shell, which they could not have entered but in a fluid form. All its organism, with regard to vegetation, seems to consist in its rind, in the little tubes whereof the juice

* I have seen vegetables, by the aid of a good microscope, so small, that they could not be discerned by the naked eye, yet through that powerful medium they appeared formidable trees, consisting of a trunk, branches, bark, leaves, blossoms, and fruit. Others were observed destitute of blossoms, and fruit, and others of leaves. It is a fact that the vegetable, extends to corresponding minutia with the animal world. And the same observations will apply equally to the former, as to the latter, that life in certain degrees and circumstances, is spontaneous, and crowds into existence, organizing, and giving form and capacity to matter independent of sexual agency, or embryotic rudiment.

runs to the extremities of the branches. And this juice petrifying, both in the cells that encompass the coraline substance, and in those at the extremity of the branches, whose substance is not yet formed, by this means enlarges the plant to its full dimensions, both in height and bulk. It is vulgarly believed, that coral is soft while in the water. But experiment proves the contrary.

It is observable that all sea-plants, (except the alga) are without roots. Nor have they any longitudinal, capillary sap-vessels, through which rooted plants draw nourishment to every part. But the whole substance of sea-plants is composed of vesicles, which receive their nourishment immediately from the surrounding water. Consequently they can have no circulation of the sap, having no vessels to convey it from one end of the plant to the other.

2. Many physicians affirm, that sugar is unwholesome, and most, that it destroys the teeth. But how will this agree with the following account? "My grandfather," says Dr. Slare, "took as much sugar as his butter spread upon bread would receive for his daily breakfast. He put sugar into all his ale and beer, and into all the sauces he used to his meat. At eighty years old he had all his teeth strong and firm (having never had the tooth-ache) and never refused the hardest crust. In his 82d year one of his teeth came out, and in two or three years all the rest. But others filled up their room, and in a short time he had a new set quite round. His hair also from very white became dark. He continued in health and strength, and died without any disease, in his ninety-ninth or hundredth year."

3. It is not only from the canes that sugar is extracted. In New-England much of it is made from the juice of the upland maple. They first make a hole in the tree, within a foot of the ground, shelving inward, so as to hold about a pint. Then they tap this hole, and by a reed draw off the liquor into a vessel. A large tree will yield, between the beginning of February and the end of April, twenty gallons of juice. A gallon, in boiling sixteen hours, is reduced to three pints, and yields more than two pounds of sugar, which our physicians prefer to all others for medicinal uses.

4. Molasses likewise may be procured without sugar-canes. This was discovered a few years ago, by Mr. Chandler, of Woodstock, in New-England, an inland town, where the common molasses is scarce and dear. Ever since both he and his neighbours supply themselves with it, out of their own orchards. The apple that produces it, is a summer sweeting, of a middling size, and full of juice. They grind and press the apple and then gently boil the juice for about six hours. In that time it comes to the sweetness and consistency, and answers all the purposes of other molasses.

5. There is one sea production, if it may be so termed, that is not commonly understood. Some have maintained, that ambergris was a substance naturally bred in one species of whales, in a bag three or four feet long. But this bag is in truth only the bladder of the whales, and the supposed ambergris is only a calculus of the bladder. The largest of these ever found in a whale weighed twenty-one pounds. But pieces of ambergris have been found, which were six feet long, and weighed above one hundred and eighty pounds.

It seems, 1. That ambergris, like yellow amber, comes out of the earth into the sea. 2. That it comes not like napththa, but in a thicker viscid and tenacious consistence. 3. That in the first formation thereof, a liquid bitumen or napththa is mixed with it. 4. That large pieces may be generated at the same time; but usually a small one rises first, to which another soon adheres, and so more and more, forming irregular figures, under which it is soft, so that various substances stick to it: but it gradually hardens to the consistence of wax.

However one would not be positive, as to the manner of its generation. For who can explain in what manner amber is produced? Or how metals, semi-metals, precious stones, and innumerable other mineral substances are generated? We know what they are, but how they are formed, we know not with any degree of certainty.

6. The principle of corruption in plants and animals, is probably the very same, which during a state of circulation, is the principle of life: namely the air, which is found in considerable quantities mixed with all sorts of fluids. This has two very different motions; an expansive one, arising from its natural elasticity, by which it gives their fluids an intestine motion, and gradually extends the parts that contain them: and a progressive motion. It does not appear that this is essential to it. Rather it is occasioned by the resistance of the solid parts. This restraining its expansion, obliges it to take the course that is more free and open, which is through the vessels of plants and animals.

When this course is stopped, the expansive motion remains, and still continues to act, till it has so fully overcome the including bodies as to bring itself to the same degree of expansion with the outward air. But this it cannot do, without destroying the texture and continuity of those solids, which we call corruption.

The destructive quality of the air is promoted, either by weakening the tone or cohesion of the including parts; as when fruit is bruised, which corrupts in that part much sooner than in the others: or by increasing the expansive force of the air, by heat, or some other co-operating circumstance.

And certainly there is no corruption or putrefaction, without air. Hence either vegetable or animal bodies buried deep in the earth or

water, remain for ages entire, which when exposed to the air, quickly moulder away. And hence such vegetables as are most apt to putrefy, remain unchanged in vacuo.

Yet various experiments seem to shew, that air must be impregnated by water, before it can occasion putrefaction, either in animal or vegetable substances. For take a pound of fresh flesh, and keep it in a moderate heat, and it will thoroughly putrefy in a few days. But if you first extract the moisture, it will harden like a stone. And it may then be kept for ages, without any putrefaction. Even blood, if you deprive it of its watery part, may be kept for fifty years. But if you then dissolve it in water, and place it in a gentle warmth, it will putrefy immediately.

The process of putrefaction may be learned from an easy experiment Take the green, juicy parts of any fresh vegetable, throw them together in a large heap, in a warm air, and lay a weight upon them. The middle part of the heap will soon conceive a small degree of heat. It will come hotter and hotter, till it comes to a boiling heat, and is perfectly putrefied.

In three days from the first putting them together, the heat will equal that of a human body in health. By the fifth day the heat will be such as the hand can hardly bear. By the seventh or eighth, all the juices are generally ready to boil. Sometimes the matter will even flame, as does moist hay, till it burns away. But commonly it acquires a cadaverous taste and smell, and turns into one soft, pulpy mass, much resembling human excrements in the scent, and putrefied flesh in the taste.

If this be distilled, there will come from it, 1. An urinous spirit, perfectly like that obtained from animals, and separable by fresh distillation into pure water, a large quantity of white, dry, volatile salt, not to be distinguished from animal salts. 2. An oily salt, which shoots into globes. 3. A thick, fœted oil, both which are entirely like those of animals. 4. The remainder being calcined in an open fire, yields not the least particle of fixed salt: just as if the subject had been of the animal, not the vegetable kingdom. And this process holds equally in all kinds of vegetables, though of ever so different natures. Yea, in dry vegetables, so they be moistened by water before they are thrown into heaps.

By this means the difference between one vegetable and another is entirely taken away. By this process, they are all reduced to one common nature: so that wormwood, for example, and sage, become one and the same thing. Nay, by this means the difference between vegetables and animals is quite taken away; putrefied vegetables being no way distinguishable from putrefied flesh. Thus is there an easy and reciprocal transition of animal into vegetable, and vegetable into animal.

So true it is, that matter, as matter, has no concern, in the qualities of bodies. All depend on the arrangement of the particles, whereof each particle consists. Hence water, though tasteless, feeds aromatic mint, and the same earth gives nourishment to bread and poison.*

As to this arrangement, the first view of a vegetable gives us an idea, of infinitely numerous and various parts: and so complex, that many have been discouraged from prosecuting the research. But

* Here the thread of elegant observation seems to be cut off abruptly, the reader might perhaps infer from hence, that there was no essential difference in organized beings; that the worm that crawls on the earth, was the same identical being as man, and a sprig of moss as the oak. But although the text observes that, "by this process all beings are reduced to one common nature: that wormwood and sage become one and the same thing. And that by these means the difference between vegetables and animals is quite taken away," yet it must be observed that it adverts to the apparent issue, and event of the process, and the means, in the expressions, "putrefied vegetables being no way distinguishable from putrefied flesh, that thus there is an easy and reciprocal transition from animal into vegetable, and vegetable into animal," implying that it is the essential principle of life, which actuates and organizes matter, and that matter, as matter has no concern in the qualities of bodies, but that all depends on the arrangement of the particles, whereof each being consists. It will appear most satisfactory to the ingenious observer, that there is a very essential and important difference between the vivifying principles which are employed in the organization of the different species of beings; that the principle which has been employed in the organization of one species is not precisely the same as that which gives life and being to another. Hence the position would be deducible, that there were as many different organizing principles, as there were different organized beings: and that there cannot be a greater variety of species than there are of specific elements; so that each particular species is derived from its own particular element. And although the chemist may be said, to reduce all bodies to the same common substance, salt, oil, acid, or gass, &c. Yet the vital electric principle, which at the command of omnipotent power, strikes the world with life, and the vital susceptibility of teeming matter, are too remote for his touch;—too subtile for his approach; these he can never arrest, these he can never come near. Could he handle these shafts of life, he himself would become a creator, he himself would bid life spring up out of the dust:—but this is alone, the prerogative of immortal and omnipotent power: the attribute of infinite wisdom.

In contemplating the whole train of organized beings, the regular gradations through which they extend, strike us at once with surprise and admiration: it would almost seem, to a nice observer, as if the whole of created being, was projected from a scale of equal parts, ascending in degrees from the lowest to the highest orders; from the minutest animalcule up to man. And such are the gradual approaches of character in the different orders, that as they advance step by step, it would almost seem, that if one did but emerge into existence, all the rest would follow in consequence. Such are the gradations by which nature conducts her operations, and so numerous are the links by which they are connected, that man with all his labour and skill, can never be able to trace them in succession, or discover perhaps the thousandth part of life, which is attached to the world in which he dwells.

upon examination, the parts which appear so numerous, are reduced to a very small account. For a careful maceration in soft water will shew, that the parts really distinct are only seven. These are, 1. An outer bark. 2. An inner rind. 3. A blea. 4. A fleshy substance. 5. A pith. There is between the flesh and the blea, 6. A vascular series. And, 7. Cones of vessels take their course within the flesh.

Whatever part of the plant we examine, we find these, be it a fibre, the root or the stem. We never find more: and tracing these, we see the other parts of the plants are only the productions of them. Thus the root, its descending fibre, and the ascending stalk, we find are one, not three substances. The same seven parts are continued from one to the other, and what are supposed at its summit, to be many new and strange parts, are found to be no more than the terminations of these seven. The external parts are also seven. 1. The cup. 2. The outer petals. 3. The inner petals. 4. The nectaria, either distinct, or connected in one ring. 5. The filaments. 6. The receptacle of seeds. And, 7. The seed-vessels or seeds. And these are only the terminations of the seven constituent substances of the plant. The outer bark terminates in the cup, the inner rind in the outward petals: the blea forms the inner petals, the vascular series ends in the nectaria, and the flesh in the filaments: the cones form the receptacle, the pith, the seed, and their capsules. These are universal in plants, though their course be less plain in some, and their terminations less distinct in others.

Every piece therefore, cut from a plant transversely, contains all the parts of the plant, ready to grow in length into a stalk upwards, and into a root downwards, and to separate at a due height from the root, into the several parts of the flower.

Thus we see the arrangement of the common particles of matter into a vegetable body, although it be a work worthy of his hand who formed it, yet is not so complex a thing as it appears. And this arrangement being once made in one individual, the species is created for ever. For growth is the consequence of the arrangement, when it has heat and moisture.

Upon the whole: if we consider every part of a plant, we shall find none without its use. The root draws nourishment from the earth: the fibres convey the sap: the larger vessels contain the specific juice of the plant: others carry air for such a respiration as it needs. The outer and inner bark in trees, defend them from heat and cold and drought, and convey that sap which is required for the annual increase of the tree. And in truth every tree may in some sense be said to be an annual plant. For both leaf, flower and fruit, proceed from the coat that was superinduced over the wood the last year. And this never bears more, but together with the old wood

serves as a block to sustain the succeeding annual coat. The leaves serve, before the bud unfolds, to defend the flower and fruit, which is even then formed; and afterward to preserve them and the branches from the injuries of the summer sun. They serve also to hinder the too hasty evaporation of the moisture about the root. But their chief use is to concoct the sap, for the nourishment of the whole plant: both that they receive from the root, and that they take in from the dew, the rain, and the moist air. Add to this, that they are as lungs, which supply the plant with the necessary quantity of air, and as excrementary ducts, which throw off superfluities by insensible perspiration. And so necessary is their service, that most trees, if quite stript of their leaves, will die. And if in summer you strip a vine-branch of its leaves, the grapes will never come to maturity. Not that they are hurt by the sun: expose them to this as you please, so the leaves remain, and they will ripen well.

Another point worthy our consideration is, the immense smallness of the seeds of some plants. Some are so extremely minute, as not at all to be discovered by the naked eye. Hence the number of seeds produced by some plants, is beyond imagination. A plant of red mace, for instance, and many sorts of fern, produce above a million: a convincing argument of the infinite understanding of the former of them.

And it is remarkable, that such mosses as grow upon walls, the roofs of houses and other high places, have seeds so excessively small, that when shaken out of their vessels, they appear like smoke or vapour. These therefore may either ascend of themselves, or by an easy impulse of the wind be raised to the tops of walls, houses, or rocks. And we need not wonder how the mosses got thither, or imagine they sprung up spontaneously.

Concerning vegetables in general, we may farther remark, 1. That because they are intended to be food for numberless species of animals, therefore nature has taken so extraordinary care, and made so abundant provision, for their propagation and increase. So that they are propagated and multiplied, not only by the seed, but also by the root: producing shoots or off-sets in some, creeping under ground in others. Some likewise are propagated by slips or cuttings; and some by several of these ways. Secondly, for the security of such species as are produced only by seed, most seeds are endued with a lasting vitality; so that if by reason of excessive cold or drought, or any other accident, they happen not to spring up the first year, they may continue their fruitfulness. I do not say six or seven only, but even twenty or thirty years. Nay, after this term, if the hindrance be removed, they will spring, and bring forth fruit. Hence it is, that plants are sometimes lost for considerable time, in places wherein

they abounded before. And after some years appear anew. They are lost either because of the unfavourable seasons; because the land was fallowed; or because plenty of weeds, or other plants, prevented their coming up. And as soon as these impediments are removed they spring up again. Thirdly, many vegetables are armed with prickles or thorns to secure them from the browzing of beasts; as also to defend others, which grow under their shelter. Hereby likewise they are made particularly useful to man, either for quick or dead fences. Fourthly, such vegetables as are weak and not able to support themselves, have a wonderful faculty, to use the strength of their neighbours, embracing and climbing up upon them, and using them as crutches to their feeble bodies. Some twist themselves about others like a screw: some lay fast hold upon them, by their curious claspers or tendrils, which herein are equivalent to hands. Some strike in a kind of root: others by the emission of a natural glue, firmly adhere to any thing which has strength sufficient to support them. Claspers are of a compound nature, between a root and a branch. Sometimes they serve for support only; as in the claspers of vines, whose branches being long and slender, would otherwise sink with their own weight: sometimes, for a supply of nourishment also; as in the trunk-roots of ivy, which mounting very high, and being of a close and very compact nature, the sap would not be sufficiently supplied to the upper sprouts, unless these assisted the mother root. Fifthly, the best of all grain, and what affords the most wholesome and agreeable nourishment is wheat. And it is most patient of all climates, bearing the extremes both of heat and cold. It grows, and brings its seed to maturity, not only in the temperate countries, but also in the cold regions of Scotland, Denmark, Norway, and Muscovy, on the one hand; and on the other, in the sultry heat of Spain, Egypt, Barbary, Mauritania, and the East-Indies. Nor is it less observable, that nothing is more fruitful. One bushel when sown in a proper soil, having been found to yield a hundred and fifty, and in some instances abundantly more.

7. It may be of use to subjoin here, first a general view of vegetation. Secondly, Some additional reflections on the vegetable kingdom.

And first. As to vegetation itself, we are sensible all our reasonings about the wonderful operations of nature, are so full of uncertainty, that, as the wise man truly observes, "Hardly do we guess aright at the things that are upon earth, and with labour do we find the things that are before us." This is abundantly verified in vegetable nature. For though its productions are so obvious to us, yet are we strangely in the dark concerning them, because the texture

of their vessels is so fine and intricate, that we can trace but few of them, though assisted with the best microscopes. But although we can never hope to come to the bottom of the first principle of things, yet may we every where see plain signatures of the hand of a Divine Architect.

All vegetables are composed of water and earth, principles which strongly attract each other: and a large portion of air, which strongly attracts when fixed, and strongly repels when in an elastic state. By combination, action, and re-action of those few principles, all the operations in vegetables are effected.

The particles of air distend each ductile part, and invigorate their sap, and meeting with the other mutually attracting principles, they are by gentle heat and motion enabled to assimilate into the nourishment of the respective parts. Thus nutrition is gradually advanced, by the nearer and nearer union of these principles, till they arrive at such a degree of consistency, as to form the several parts of vegetables. And at length, by the flying off of the watery vehicle, they are compacted into hard substances.

But when the watery particles again soak into and disunite them, then is the union of the parts of vegetables dissolved, and they are prepared by putrefaction, to appear in some new form, whereby the nutritive fund of nature can never be exhausted.

All these principles are in all parts of vegetables. But there is more oil in the more exalted parts of them. Thus seeds abound with oil, and consequently with sulphur and air. And indeed as they contain the rudiments of future vegetables, it was necessary they should be stored with principles, that would both preserve them from putrefaction, and also be active in promoting germination and vegetation.

And as oil is an excellent preservative against cold, so it abounds in the sap of the more northern trees. And it is this by which the evergreens are enabled to keep their leaves all the winter.

Leaves not only bring nourishment from the lower parts within the attraction of the growing fruit, (which like young animals is furnished with proper instruments to suck it thence) but also carry off redundant watery fluids, while they imbibe the dew and rain, which contain much salt and sulphur, for the air is full of acid and sulphureous particles; and the various combinations of these, are doubtless very serviceable in promoting the work of vegetation. Indeed, so fine a fluid as the air, is a more proper medium, wherein to prepare and combine the more exalted principles of vegetables, than the gross watery fluid of the sap. And that there is plenty of these particles in the leaves is evident, from the sulphureous exudations often found

on their edges. To these refined æreal particles, not only the most racy, generous taste of fruits, but likewise the most grateful odours of flowers, yea, and their beautiful colours, are probably owing.

In order to supply tender shoots with nourishment, nature is careful to furnish, at small distances, the young shoots of all sorts of trees with many leaves throughout their whole length, which as so many jointly acting powers, draw plenty of sap to them.

The like provision has nature made, in the corn, grass, and reed-kind: the leafy spires, which draw nourishment to each joint, being provided long before the stem shoots: the tender stems would easily break, or dry up, so as the prevent their growth, had not these scabbards been provided, which both support and keep them in a supple and ductile state.

The growth of a young bud to a shoot, consists in the gradual dilation and extension of every part, till it is stretched out to its full length. And the capillary tubes still retain their hollowness, notwithstanding their being extended, as we see melted glass tubes remain hollow, though drawn out to the finest thread.

The pith of trees is always full of moisture, while the shoot is growing, by the expansion of which, the tender, ductile shoot is distended in every part. But when each year's shoot is fully grown, then the pith gradually dries up. Mean time nature carefully provides for the growth of the succeeding year, by preserving a tender, ductile part in the bud, replete with succulent pith. Great care is likewise taken to keep the parts, between the bark and wood always supple with slimy moisture, from which ductile matter the woody fibres, vesicles, and buds are formed.

The great variety of different substances in the same vegetable proves, that there are peculiar vessels for conveying different sorts of nutriment. In many vegetables some of those vessels are plainly to be seen full of milky, yellow, or red nutriment.

Where a secretion is designed to compose a hard substance, viz. the kernel or seed of hard-stone fruits, it does not immediately grow from the stone, which would be the shortest way to convey nourishment to it. But the umbilicle vessel fetches a compass round the concave of the stone, and then enters the kernel near its cone. By this artifice the vessel being much prolonged, the motion of the sap is thereby retarded, and the viscid nutriment conveyed to the seed, which turns to a hard substance.

Let us trace the vegetation of a tree, from the seed to its full maturity. When the seed is sown, in a few days it imbibes so much moisture, as to swell with very great force, by which it is enabled both to strike its roots down, and to force its stem out of the ground. As it grows up, the first, second, third, and fourth order of lateral

ranches shoot out, each lower order being longer than those immediately above them: not only as shooting first, but because inserted nearer the root, and so drawing greater plenty of sap. So that a tree is a complicated engine, which has as many different powers as it has branches. And the whole of each yearly growth of the tree, is proportioned to the whole of the nourishment they attract.

But leaves also are so necessary to promote its growth, that nature provides small, thin, expansions, which may be called primary leaves; they draw nourishment to the buds and young shoots, before the leaf is expanded. These bring nutriment to them in a quantity sufficient for their small demand: a greater quantity of which is afterward provided, in proportion to their need, by the greater expansion of the leaves. A still more beautiful apparatus we find in the curious expansions of blossoms and flowers, which both protect and convey nourishment to the embryo, fruit and seeds. But as soon as the calix is formed into a small fruit, containing a minute, seminal tree the blossom falls off, leaving it to imbibe nourishment for itself, which is brought within the reach of its suction, by the adjoining leaves.

I proceed to make some additional reflections upon the vegetable kingdom.

All plants produce seeds: but they are entirely unfit for propagation, till they are impregnated. This is performed within the flower, by the dust of the antheræ falling upon the moist stigmata, where it bursts, and sends forth a very subtle matter, which is absorbed by the style and conveyed down to the seed. As soon as this operation is over, those organs wither and fall. But one flower does not always contain all these: often the male organs are on one, the female, on another. And that nothing may be wanting, the whole apparatus of the antheræ and stigmata is in all flowers contrived with wonderful wisdom. In most, the stigmata surround the pistil, and are of the same height. But where the pistil is longer than the stigmata, the flowers recline, that the dust may fall into the stigma, and when impregnated rise again, that the seeds may not fall out. In other flowers the pistil is shorter, and there the flowers preserve an erect situation. Nay, when the flowering season comes on, they become erect though they were drooping before. Lastly, when the male flowers are placed below the female, the leaves are very small and narrow, that they may not hinder the dust from flying upwards like smoke: and when in the same species one plant is male, and the other female, there the dust is carried in abundance by the wind from the male to the female. We cannot also without admiration observe, that most flowers expand themselves when the sun shines, and close when either rain, clouds, or evening is coming on, lest the genital dust should be coagulated, or otherwise rendered useless. Yet when the

impregnation is over, they do not close, either upon showers or the approach of evening.

For the scattering of seed nature has provided numberless ways. Various berries are given for food to animals; but while they eat the pulp, they sow the seed. Either they disperse them at the same time; or if they swallow them, they are returned with interest. The mistletoe always grows on other trees; because the thrus that eats the seeds of them, casts them forth with his dung. The junipers also, which fill our woods, are sown in the same manner. The cross-bill that lives on fir-cones, and the haw-finch which feeds on pine-cones, sow many of those seeds, especially when they carry the cone to a stone or stump, to strip off its scales. Swine likewise, and moles by throwing up the earth, prepare it for the reception of seeds.

The great Parent of all decreed, that the whole earth should be covered with plants. In order to this he adapted the nature of each to the climate where it grows. So that some can bear, intense heat, others intense cold. Some love a moderate warmth. Many delight in dry, others in moist ground. The Alpine plants love mountains whose tops are covered with eternal snow. And they blow and ripen their seeds very early, lest the winter should overtake and destroy them. Plants which will grow no where else, flourish in Siberia, and near Hudson's bay. Grass can bear almost any temperature of the air, in which the good providence of God appears: this being so necessary all over the globe, for the nourishment of cattle.

Thus, neither the scorching sun nor the pinching cold hinders any country from having its vegetables. Nor is there any soil which does not bring forth some. Pond-weed and water-lillies inhabit the waters. Some plants cover the bottom of rivers and seas: others fill the marshes. Some clothe the plains: others grow in the driest woods, that scarce ever see the sun. Nay, stones and the trunks of trees are not void, but covered with liverwort.

The wisdom of the Creator appears no where more, than in the manner of the growth of trees. As their roots descend deeper than those of other plants, they do not rob them of nourishment. And as their stems shoot up so high, they are easily preserved from cattle. Their leaves falling in autumn guard many plants against the rigour of winter; and in summer afford both them and us a defence against the heat of the sun. They likewise imbibe the water from the earth, part of which transpiring through their leaves, is insensibly dispersed, and helps to moisten the plants that are round about. Lastly, the particular structure of trees contributes very much to the

propagation of insects. Multitudes of these lay their eggs upon their leaves, where they find both food and safety.

Many plants and shrubs are armed with thorns, to keep the animals from destroying their fruits. At the same time these cover many other plants, under their branches, so that while the adjacent grounds are robbed of all plants, some may be preserved to continue the species.

The mosses which adorn the most barren places, preserve the smaller plants when they begin to shoot from cold and drought. They also hinder fermenting earth from forcing the roots of plants upward in the spring, as we see happen annually to trunks of trees. Hence few mosses grow in southern climates, not being necessary.

Sea-matweed will bear no soil but pure sand. Sand is often blown by violent winds, so as to deluge as it were meadows and fields. But where this grows, it fixes the sand, and gathers it into hillocks. Thus other lands are formed, the ground increased, and the sea repelled, by this wonderful disposition of nature.

How careful is nature to preserve that useful plant grass! The more its leaves are eaten, the more they increase. For the Author of nature intended, that vegetables which have slender stalks and erect leaves should be copious and thick set, and thus afford food for so vast a quantity of grazing animals. But what increases our wonder, is, that although grass is the principal food of such animals, yet they touch not the flower and seed bearing stems, that so the seeds may ripen and be sown.

The caterpillar of the moth, which feeds upon grass to the destruction thereof, seems to be formed in order to keep a due proportion between this and other plants. For grass when left to grow freely, increases to that degree as to exclude all other plants, which would consequently be extirpated, unless the insect sometimes prepared a place for them. And hence it is, that more species of plants appear, when this caterpillar has laid waste the pasture the preceding year, than at any other time.

But all plants, sooner or later, must submit to death. They spring up, they grow, they flourish, they bear fruit, and having finished their course, return to the dust again. Almost all the black mould which covers the earth is owing to dead vegetables. Indeed after the leaves and stems are gone, the roots of plants remain: but these too, at least rot and change into mould. And the earth thus prepared, restores to plants what it has received from them. For when seeds are committed to the earth, they draw and accommodate to their own nature the more subtle parts of this mould: so that the tallest tree is in reality nothing but mould wonderfully compounded with air and

water. And from these plants, when they die, just the same kind of mould is formed as gave them birth. By this means fertility remains continually uninterrupted: whereas the earth could not make good its annual consumption, were it not constantly recruited.

In many cases, the crustaceous liverworts are the first foundation of vegetation. Therefore, however despised, they are of the utmost consequence, in the economy of nature. When rocks first emerge out of the sea, they are so polished by the force of the waves, that hardly any herb is able to fix its habitation upon them. But crustaceous liverworts soon begin to cover these dry rocks, though they have no nourishment but the little mould and imperceptible particles, which the air and rain bring thither. These liverworts dying turn into fine earth, in which a larger kind of liverworts strike their roots. These also die and turn into mould: and then the various kinds of mosses find nourishment. Lastly, these dying yield such plenty of mould, that herbs and shrubs easily take root and live upon it.

That trees, when dry or cut down, may not remain useless to the world, and lie melancholy spectacles, nature hastens on to their destruction, in a singular manner. First the liverworts begin to strike root in them; afterward the moisture is drawn out of them, whence putrefaction follows. Then the mushroom-kind find a fit place to grow on, and corrupt them still more. A particular sort of beetle next makes himself a way between the bark and the wood. Then a sort of caterpillar, and several other sorts of beetles, bore numberless holes through the trunk. Lastly, the woodpeckers come, and while they are seeking for insects, shatter the tree, already corrupted, and exceedingly hasten its return to the earth from whence it came. But how shall the trunk of a tree, which is immersed in water, ever return to earth? A particular kind of worm performs this work, as sea-faring men know.

But why is so inconsiderable a plant as thistles, so armed and guarded by nature? Because it is one of the most useful plants that grows. Observe a heap of clay, on which for many years no plant has sprung up: let but the seeds of a thistle fix there, and other plants will quickly come thither, and soon cover the ground. For the thistles by their leaves attract moisture from the air, and by their roots send it into the clay, and by that means not only thrive themselves, but provide a shelter for other plants.

I shall add only one observation more, concerning the difference between natural and artificial things. If we examine the finest needle by the microscope, the point of it appears about a quarter of an inch broad, and its figure neither round, nor flat, but irregular and unequal. And the surface, however smooth and bright it may seem to the naked eye, is then seen full of raggedness, holes, and scratches,

like an iron bar from the forge. But examine in the same manner the sting of a bee, and it appears to have in every part a polish most amazingly beautiful, without the least flaw or inequality, and ends in a point too fine to be discerned by any glass whatever. And yet this is only the outward sheath of far more exquisite instruments.

A small piece of the finest lawn, from the distance and holes between its threads, appears like a lattice or hurdle. And the threads themselves seem coarser than the yarn wherewith ropes are made for anchors. Fine Brussels lace will look as if it were made of a thick, rough, uneven hair-line, entwisted or clotted together, in a very awkward and unartful manner. But a silk-worm's webb on the nicest examination appears perfectly smooth and shining, and as much finer than any spinster in the world can make, as the smallest twine is than the thickest cable. A pod of this silk winds into nine hundred and sixty yards. And as it is two threads twisted together all the length, so it really contains one thousand eight hundred and sixty: and yet weighs but two grains and a half. What an exquisite fineness! and yet this is nothing to the silk that issued from the worm's mouth when newly hatched.

The smallest dot which can be made with a pen, appears through a glass, a vast irregular spot, rough, jagged and uneven about all its edges. The finest writing, such as the Lord's prayer in the compass of a silver penny, seems as shapeless and uncouth as if wrote in Runic characters. But the specks of moths, beetles, flies and other insects, are most accurately circular; and all the lines and marks above them are drawn to the utmost possibility of exactness.

Our finest miniature paintings appear, before a microscope, as mere daubings, plastered on with a trowel. Our smoothest polishings are shewn to be mere roughness, full of gaps and flaws. Thus do the works of art sink, upon an accurate examination. On the contrary, the nearer we examine the works of nature, even in the least and meanest of her productions, the more we are convinced, nothing is to be found there but beauty and perfection. View the numberless species of insects; what exactness and symmetry shall we find in all their organs! What a profusion of colouring, azure, green, vermillion; what fringe and embroidery on every part! How high the finishing, how inimitable the polish we every where behold! Yea, view the animalcula, invisible to the naked eye, those breathing atoms so small, they are almost all workmanship: in them too we discover the same multiplicity of parts, diversity of figures, and variety of motions, as in the largest animals. How amazingly curious must the internal structure of these creatures be! How minute the bones, joints, muscles, and tendons! How exquisitely delicate the veins, arteries, nerves! What multitudes of vessels and

circulations must be contained in this narrow compass! And yet all have sufficient room for their several offices, without interfering with each other.

The same regularity and beauty is found in vegetables. Every stalk, bud, flower, and seed, displays a figure, a proportion, a harmony, beyond the reach of art. There is not a weed whose every leaf does not shew a multiplicity of pores and vessels curiously disposed for the conveyance of juices, to support and nourish it, and which is not adorned with innumerable graces to embellish it.

But some may ask, to what purpose has nature bestowed so much expense on so insignificant creatures? I answer, this very thing proves they are not so insignificant, as we fondly suppose. This beauty is given them either for their own sake, that they themselves may be delighted with it: or for ours, that we may observe in them the amazing power and goodness of the Creator. If the former, they are of consequence in the account of their Maker, and therefore deserve our regard. If the latter, then it is certainly our duty to take notice of, and admire them.

In short, the whole universe is a picture, in which are displayed the perfections of the Deity. It shews not only his existence, but his unity, his power, his wisdom, his independence, his goodness. His unity appears in the harmony we cannot but see in all the parts of nature; in that one simple end to which they are directed, and the conformity of all the means thereto. On every side we discern either simple elements or compound bodies, which have all different actions and offices. What the fire inflames, the water quenches: what one wind freezes, another thaws. But these and a thousand other operations, so seemingly repugnant to each other, do nevertheless all concur in a wonderful manner, to produce one effect. And all are so necessary to the main design, that were the agency of any one destroyed, an interruption of the order and harmony of the creation must immediately ensue.

Suppose, for instance, the wind to be taken away, and all society is in the utmost disorder. Navigation is at a stand, and all our commerce with foreign nations destroyed. On the other hand, the vapours raised from the sea would remain suspended just where they rose. Consequently we should be deprived of that useful covering, the clouds, which now screens us from the scorching heat: yea, and of the fruitful rains. So our land would be parched up, the fruits of the earth wither, animals die, through hunger and thirst, and all nature languish and droop. All the parts of nature therefore were constituted for the assistance of each other, and all undeniably prove the unity of their Omniscient Creator.

His power appears in the whole frame of creation, and his wisdom in every part of it. His independence is pointed out in the inexhaustible variety of beasts, birds, fishes and insects : and his goodness, in taking care of every one of these, opening his hand, and filling all things living with plenteousness.

Every thing is calculated by Divine Wisdom, to make us wiser and better. And this is the substance of true philosophy. We cannot know much. In vain does our shallow reason attempt to fathom the mysteries of nature, and to pry into the secrets of the Almighty. His ways are past finding out. The eye of a little worm is a subject capable of exhausting all our boasted speculations. But we may love much. And herein we may be assisted by contemplating the wonders of his creation. Indeed he seems to have laid the highest claim to this tribute of our love, by the care he has taken to manifest his goodness in the most conspicuous manner, while at the same time he has concealed from us the most curious particulars, with regard to the essences and structure of his works. And to our ignorance it is owing, that we fancy so many things to be useless in the creation. But a deep sense of his goodness will satisfy all our doubts, and resolve all our scruples.

8. I cannot conclude this part better, than with an essay on the production, nourishment, and operation of plants and animals.

SECTION I.

Creatures produce their own kind.

When I survey the works of nature with an attentive eye, I am surprised to find with what marvellous exactness every creature draws its own picture, or propagates its own likeness, though in different manners of operation. The fox produces a living fox; the goose drops her egg, and hatches the young goose ; and the tulip lets fall its seed into the earth, which ferments and swells, and labours long in the ground, till at last it brings forth a tulip.

Is it the natural sagacity of foxes that enables them to form their own image so accurately ? By no means : for the goose and the flower do the like : the sprightly and the stupid, the sensible and the senseless, work this wonder with equal regularity and perfection ; and the plant performs it as well the animal.

It is not possible that any of them should effect this by any peculiar rules of art and contrivance : for neither the one nor the other are at all acquainted with the composition or progress of their work. The bird is entirely ignorant of the wondrous vital ferment of her own

egg, either in the formation of it, or the incubation: and the mother-plant, knows as much of the parts of the young plant, as the mother-animal knows of the inward springs and movements of the young little animal. There could be no contrivance here: for not any of them had any thought or design of the final production: they were all moved, both the beast, bird, and flower, by the material and mechanical springs of their own nature to continue their own species, but without any such intent or purpose.

Give souls to all the animal race, and make those souls as intelligent as you can; attribute to them what good sense you please in other affairs of their puny life; allow the brutes to be as rational and as cunning as you could wish or fancy, and to perform a thousand tricks by their own sagacity; yet in this matter, those intellectual powers must all stand by as useless: the senseless vegetable has as much skill here as the animal: the goose is as wise as the fox or the greyhound; they draw their own portraits with an exquisite art and accuracy, and leave as perfect images behind them to perpetuate their kind. Amazing proof and incontestible argument of some superior wisdom: some transcendent contriving mind: some divine artificer that made all these wondrous machines, and set them at work! The animal and the vegetable in these productions are but mere instruments under his supreme ruling power; like artless pencils in a painter's hand, to form the images that his thought had before designed: and it is that God alone, who before all worlds contrived these models of every species in his own original idea, that appoints what under-agents he will employ to copy them.

In the week of the creation, he bade earth teem with beasts and plants; and the earth like a common mother brought forth the lion, the fox and the dog, as well as the cedar and the tulip. Gen. i. 11, 24. He commanded the water to produce the first fish and fowl: and behold the waters grow pregnant; the trout and the dolphin break forth into life; the goose and the sparrow arise and shake their wings. Gen. i. 20, 21. But two common parents, earth and water, to the whole animal and vegetable world! A God needs no more. And though he was pleased to make use of the water and the earth in these first productions, yet the power and the skill were just the same as if he had made them immediately with his own hands.

Ever since that week of creative wonders, God has ordered all these creatures to fill the world with inhabitants of their own kind; and they have obeyed him in a long succession of almost six thousand years. He has granted (shall I say) a divine patent to each creature for the sole production of its own likeness, with an utter prohibition to all the rest; but still under the everlasting influence of his own

supreme agency upon the moving atoms that form these plants or animals. God himself is the creator still.

And it is evident that he has kept a reserve of sovereignty to himself, and has displayed the ensigns of it in some important hours.—Egypt was once a glorious and tremendous scene of this sovereignty: it was there that he ordered the rod of Moses, a dry and lifeless vegetable, to raise a swarm of living animals, to call up a brood of lice in millions, without a parent, and to animate the dust of the ground into a noisome army.

It was there he bid Moses wave the same rod over the streams and the ponds, and the silent rod under divine influence would bring forth croaking legions out of the waters without number.

But these are his works of miracle and astonishment, when he has a mind to shew himself the sovereign and the controller of nature: without his immediate commission not one creature can invade the province of another, nor perform any thing of this work but within its own peculiar tribe. Even man, the glory of this lower creation and the wisest thing on earth, would in vain attempt to make one of these common vegetables, or these curious animated moving machines. Not all the united powers of human nature, nor a council of the nicest artificers with all their enginery and skill, can form the least part of these works, can compose a fox's tail, a goose-quill, or a tulip leaf. Nature is the art of God, and it must for ever be unrivalled by the sons of men.

Yet man can produce a man. Admirable effect, but artless cause! A poor, limited, inferior agent! The plant and the brute in this matter are his rivals, and his equals too. The human parent and the parent bird form their own images with equal skill, and are confined each to its own work. So the iron seal transfers its own figure to the clay with as much exactness and curiosity as the golden one; both can transfer only their own figure.

This appears to be a glorious instance wherein the wisdom and power of God maintain their own supremacy, and triumph over all the boasted reason and intellectual skill of men: that the wisest son of Adam, in this noblest work of nature, can do no more than a flower or a fly; and if he would go out of his species, and the appointed order of things, he is not able to make a fly, or a flower; no, not a worm, nor a simple bulrush. In those productions wherein mankind are merely the instruments of the God of nature, their work is vital and divine; but if they would set up for prime artificers, they can do nothing: a dead statue, a painted shadow on a canvas, or perhaps a little brazen clock work is the supreme pride of their art, their highest excellence and perfection.

Let the atheist then exert his utmost stretch of understanding: let him try the force of all his mechanical powers, to compose the wing of a butterfly, or the meanest feather of a sparrow: let him labour, and sweat and faint, and acknowledge his own weakness: then let him turn his eye, and look at those wondrous composures, his son, or his little daughter, and when their infant tongues shall inquire of him, and say, *Father, who made us?* let him not dare assume the honour of that work to himself, but teach the young creatures that *there is a God*, and fall down on his face, and repent and worship.

It was God who said at first, "Let the earth bring forth grass, and the herb yielding seed, after his kind, and the living creature after his kind;" and when this was done, then with a creating voice he bid those herbs and those living creatures, "be fruitful and multiply" to all future generations. "Great things doth he which we cannot comprehend. But he sealeth up the hand of every man, that all men may know his *divine* work." *Gen.* i. 11, 25. *Job* xxxvii. 5, 7.

SECTION II.

The laws of nature sufficient for the production of animals and vegetables.

Will you suppose that it derogates from the glory of divine Providence, to represent the great engine of this visible world, as moving onward in its appointed course, without the continual interposure of his hand? It is granted, indeed, that his hand is ever active in preserving all the parts of matter, in all their motions, according to these uniform laws: but I think it is rather derogatory to his infinite wisdom, to imagine that he would not make the vegetable and animal, as well as the inanimate world, of such sort of workmanship, as might regularly move onward in this manner for five or six thousand years, without putting a new hand to it ten thousand times every hour: I say, *ten thousand times* every hour: for there is not an hour nor a moment passes, wherein there are not many millions of plants and animals actually forming in the southern or northern climates.

He that can make a clock, with a great variety of beauties and motions, to go regularly a twelvemonth together, is certainly a skilful artist; but if he must put his own hand to assist those motions every hour, or else the engine will stand still, or the wheels move at random, we conceive a much meaner opinion of his performance and his skill. On the other hand, how glorious and divine an artificer would he be called, that should have made two of these pieces of clock-work above five thousand years ago, and contrived such hidden springs and motions within them that they should have joined together, to per-

petuate the species, and thus continue the same sort of clocks in more than a hundred successions down to this day! though each of their springs might fail in forty years time, and their motions cease, or their materials decay, yet that by the means of these two original engines, there should be engines of the same kind multiplied upon the face of the earth, by the same rules of motion which the artist had established in the day when he first formed them?

Such is the workmanship of God; for *nature* is nothing but his *art*. Such is the amazing penetration of divine skill; such the long reach of his foresight, who has long ago set his instruments at work, and guarded against all their possible deficiencies; who has provided to replenish the world with plants and animals to the end of time, by the wondrous contrivance of his creation, and the laws he then ordained.

Thus every whale, eagle and apple-tree, every lion and rose, fly and worm in our age, are as really the work of God, as the first which he made of the kind. It is so far from being a derogation to his honour, to perpetuate all the species by such instruments of his agency for many ages, that it rather aggrandizes the character of the Creator, and gives new lustre to Divine Wisdom: for if any thing can be said to be easier or harder in this sort of Almighty work, we may suppose it a more glorious difficulty for a God to employ a sparrow or an oyster to make a sparrow or an oyster, than to make one immediately with his own hand. Perhaps there is not a wasp or a butterfly now in the world, but has gone through almost six thousand ancestors, and yet the work of the last parent is exquisitely perfect in shape, in colour, and in every perfection of beauty; but it is all owing to the first cause.

This is wisdom becoming a God, and demands an eternal tribute of wonder and worship.

SECTION III.

Of the nourishment and growth of plants.

In the beginning of time and nature, at the command of God, the earth brought forth plants and herbs, and four-footed animals in their various kinds; but the birds of the air, as well as the fishes, were produced by the same command out of the waters. This was intimated in a former section. The water and the earth were the first appointed *mothers*, if I may so express it, of all the animal and vegetable creation. Since that time they cease to be *parents* indeed, but they are the common *nurses* of all that breathes, and of all that grows. Nor is the wisdom of God much less conspicuous in constituting two

such plain and simple beings as the earth and water, to be the springs of nourishment and growth to such an innumerable variety of creatures, than it was in the formation of them out of two such materials. Is it not counted an admirable piece of divine contrivance and wisdom, that the single principle of gravitation should be employed by the Creator, to answer so many millions of purposes among the heavenly bodies in their regular revolutions, as well as among the inhabitants, and the furniture of this earthly globe where we dwell? And may it not be esteemed as astonishing an effect of the same supreme wisdom, that two such simple things as water and earth should be the common materials out of which all the standing ornaments, the vegetable beauties, and the moving inhabitants, of this our world, whether flying or creeping, walking or swimming, should receive their continual sustenance and their increase!

Let us first consider this as it relates to the vegetable part of the creation. What a profusion of beauty and fragrancy, of shapes and colours, of smells and tastes, is scattered among the herbs and flowers of the ground, among the shrubs, the trees and the fruits of the field! Colouring in its original glory and perfection triumphs here; red, yellow, green, blue, purple, with vastly more diversities than the rainbow ever knew, or the prism can represent, are distributed among the flowers and blossoms. And what variety of tastes, both original and compounded, of sweet, bitter, sharp, with a thousand nameless flavours, are found among the herbs of the garden! What an amazing difference of shapes and sizes appears amongst the trees of the field and forest in their branches and their leaves! And what a luxurious and elegant distinction in their several fruits! How very numerous are their distinct properties, and their uses in human life! And yet these two common elements, earth and water, are the only materials out of which they are all composed, from the beginning to the end of nature and time!

Let the gardener dress for himself one field of fresh earth, and make it as uniform as he can; then let him plant therein all the varieties of the vegetable world, in their roots or in their seeds, as he shall think most proper: yet out of this common earth, under the droppings of common water from Heaven, every one of these plants shall be nourished, and grow up in its proper form; all the infinite diversity of shapes and sizes, colours, tastes and smells which constitute and adorn the vegetable world, (would the climate permit) might be produced out of the same clods. What rich and surprising wisdom appears in that Almighty Operator, who out of the same matter shall perfume the bosom of the rose, and give the garlic its offensive and nauseous powers! Who, from the same spot of ground, shall raise liquorice and the wormwood! and dress the cheek of the tulip in all

its glowing beauties! What a surprise, to see the same seed furnish the pomegranate and the orange tree with the juicy fruit, and the stalks of corn with their dry and husky grains! To observe the oak raised from a little acorn, into its stately growth and solid timber, out of the same bed of earth that sent up the vine with such soft and feeble limbs! What a natural kind of prodigy is it, that chilling and burning vegetables should arise out of the same spot! That the fever and the frenzy should start up from the same bed, where the palsy and the lethargy lie dormant in their seeds! Is it not exceeding strange, that healthful and poisonous juices should rise up in their proper plants out of the same common glebe, and that life and death should grow and thrive within an inch of each other.

What wondrous and inimitable skill must be attributed to that Supreme Power, that first cause, who can so infinitely diversify effects, where the servile second cause is always the same!

It is not for me in this place to enter into a long detail of philosophy, and shew how the minute fibres and tubes of the different seeds and roots of vegetables take hold of, attract, and receive the little particles of earth and water proper for their own growth; how they form them at first into their own shapes, and send them up aspiring above ground by degrees, and mould them so as to frame the stalks, the branches, the leaves and the buds of every flower, herb, and tree. But I presume the world is too weary of substantial forms, and plastic powers, to be persuaded that these mere creatures of fancy should be the operators in this wondrous work. It is much more honourable to attribute all to the design and forethought of God, who formed the first vegetables in such a manner, and appointed their little parts to ferment under the warm sunbeams, according to such established laws of motion, as to mould the atoms of earth and water which were near them into their own figure, to make them grow up into trunk and branches, which every night should harden into firmness and stability; and again, to mould new atoms of the same element into leaves and bloom, fruit and seed, which last being dropt into the earth, should produce new plants of the same likeness, to the end of the world.

It is easier for the sons of men to stand and wonder, and adore God the Creator, than to imitate, or even describe his admirable works. In the best of their descriptions and their imitations of this divine artist, they do but chatter like Hottentots, and paint like Goths and Vandals.

SECTION IV.

Of the nourishment and growth of animals.

Let us proceed in the next place to survey new wonders. All the animals of the creation, as well as the plants, have their original nourishment from these simple materials, earth and water. For all the animal beings which do not live upon other animals, or the produce of them, take some of the vegetables for their food; and thus the brutes of prey are originally indebted to the plants and herbs, i. e. to the earth, for their support, and their drink is the watery element. That all flesh is grass, is true, in the literal, as well as the metaphorical sense. Does the lion eat the flesh of the lamb? Doth the lamb suck the milk of the ewe? But the ewe is nourished by the grass of the field. Does the kite devour the chicken, and the chicken the little caterpillars, or insects of the spring? But these insects are ever feeding on the tender plants, and the green products of the ground. The earth moistened with water is the common nurse of all. Even the fishes of the sea are nourished with vegetables that spring up there, or by preying on lesser fishes which feed on these vegetables.

But let us give our meditations a loose on this entertaining subject, and we shall find numerous instances of wonder in this scene of Divine contrivance.

1. What very different animals are nourished by the same vegetable food! The self-same herbage or fruits of the earth by the divine laws of nature and providence, are converted into animated bodies of very different kinds. Could you imagine that half the fowls of the air, as different as they are, from the crow to the tit-mouse, should derive their flesh and blood from the productions of the same tree, where the swine watch under the boughs of it, and are nourished by the fruit? Nor need I stay to take notice what numerous insects find their nests and their food all the summer season, from the same apples or apricots, plumbs or cherries, which feed hogs and crows, and a hundred small birds. Would you think that the black and the brindled kine, with the horses both gray and bay, should clothe themselves with their hairy skins of so various colours, out of the same green pasture where the sheep feed, and cover themselves with their white and woolly fleece? And at the same time the goose is cropping part of the grass to nourish its own flesh, and to array itself with down and feathers. Strange and stupendous texture of the bodies of these creatures, that should convert the common green herbage of the field

into their different natures, and their more different clothing! But this leads me to another remark.

2. What exceeding great diversity is found in the several parts, limbs and coverings even of the same creature! An animated body is made up of flesh and blood, bones and membranes, long, hollow tubes, with a variety of liquors contained in them, together with many strings and tendons, and a thousand other things which escape the naked sight, and for which anatomy has hardly found a name; yet the very same food is by the wondrous skill and appointment of the God of nature, formed into all these amazing differences. Let us take an ox to pieces, and survey the wondrous composition. Besides the flesh of this huge living structure, and the bones on which it is built, what variety of tender coats and humours belong to that admirable organ the eye! How solid and hard are the teeth which grind the food! How firm the general ligaments that tie the joints of that creature together! What horny hoofs are his support, and with what different sort of horny weapons has nature furnished his forehead! Yet they are all framed of the same grassy materials: the calf grazes upon the verdant pasture, and all its limbs and powers grow up out of that food to the size and firmness of an ox. Can it be supposed, that all these corpuscles, of which the several inward and outward parts of the brute are composed, are actually found in their different and proper forms in the vegetable food? Does every spire of grass actually contain the specific parts of the horn and the hoof, the teeth and the tendons, the glands and membranes, the humours and coats of the eye, the liquids and solids, with all their innumerable varieties, in their proper distinct forms? This is a most unreasonable supposition. No, it is the wisdom of the God of nature that distributes this uniform food in the several parts of the animal, by his appointed laws, and gives proper nourishment to each of them.

Again, 3. If the food of which one single animal partakes, be never so various and different, yet the same laws of motion, which God has ordained in the animal world, convert them all to the same purposes of nourishment for that creature. Behold the little bee gathering its honey from a thousand flowers, and laying up the precious store, for its winter food! Mark how the crow preys upon a carcase; anon it crops a cherry from the tree, and both are changed into the flesh and feathers of a crow. Observe the kine in the meadows, feeding on a hundred varieties of herbs and flowers; yet all the different parts of their bodies are nourished thereby in a proper manner: every flower in the field is made use of to increase the flesh of the heifer, and to make food for man: and out of all these varieties, there is a noble milky juice flowing to the udder, which provides nourishment for young children.

So near akin is man, the lord of the creation, in respect of his body, to the brutes that are his slaves, that the very same food will compose the flesh of both, and make them grow up to their appointed stature. This is evident beyond doubt in daily experiments. The same bread-corn which we eat at our tables will give rich support to sparrows and pigeons, to the turkey and the duck, and all the fowls of the yard: the mouse steals it and feeds on it in his dark retirements; while the hog in the sty and the horse at the manger, would be glad to partake of it. When the poor cottager has nursed up a couple of geese, the fox seizes one of them for the support of her cubs, and perhaps the table of the landlord is furnished with the other to regale his friends. Nor is it an uncommon thing to see the favourite lap-dog fed out of the same bowl of milk which is prepared for the heir of a wealthy family, but which nature had originally designed to nourish a calf. The same milky material will feed calves, lap-dogs, and human bodies.

How various are our dishes at an entertainment! How has luxury even tired itself in the invention of meats and drinks in an excessive and endless variety! Yet when they pass into the common boiler of the stomach, and are carried thence through the intestines, there is a white juice strained out of the strange mixture, called chyle, which from the lacteal vessels is converted into the blood, and by the laws of nature is conveyed into the same crimson liquor. This being distributed through all the body by the arteries, is farther strained again through proper vessels, and becomes the spring of nourishment to every different part of the animal. Thus the God of nature has ordained, that how diverse soever our meats are, they shall first be reduced to an uniform milky liquid, that by new contrivances and Divine art, it may be again diversified into flesh and bones, nerves and membranes.

How conspicuous, and yet how admirable are the operations of Divine Wisdom in this single instance of nourishment! But it is no wonder that a God who could create such astonishing and exquisite pieces of machinery, as plants and animals, could prescribe such laws to matter and motion, as to nourish and preserve the individuals, as well as to propagate the species, through all ages, to the end of time.

SECTION V.

The similar operations of plants and animals.

It is with admiration and pleasure we take notice of the regular actions of animals even in their earliest hours of life, before they can possibly be taught any thing by remark or imagination. Observe the

young sparrows in the nest: see how the little, naked creatures open their mouths wide to their dam, as though they were sensible of their dependence on her care for food and nourishment. But the chicken just released from the prison of the shell, can pick up its food with its own bill, and therefore it doth not open its mouth to beg food of the hen that hatched it. Yet the chicken seems to shew its dependence too; for when the first danger appears, you see it run and fly to the wing of its dam for protection; as if it knew, that though it could feed itself, yet it was not able to defend itself, but must trust to the better security of a parent's wing.

We admire these little creatures and their remarkable sagacity; we are surprised to find that they distinguish so happily, and pursue their proper interest; that they are so soon acquainted with their abilities and their wants, and come to use their understanding so very early; for it is evident, that the mere faculty of sense, that is, the passive reception of images or ideas, can never be sufficient to account for these wondrous imitations of reason: sense has nothing to do but with the present impression, and includes no reflection or prospect of the past or the future, no contrivance of means to an end, nor any action in order to obtain it.

But what shall we say, or how shall we account for it, if we are told there are instances almost as admirable as these to be found in the vegetable world, where we never suspect sense or reason? The vine, as though it were sensible of its own weakness, thrusts forth its long tendrils, which curl round the branches of any stronger tree that stands near, and thus it hangs its weighty clusters upon the arms of the elm that support it. Nay, every cluster has a tendril belonging to it, and if any stronger twig of its own be within its reach, it hangs itself there by this tendril for support. The hop and the lupin, or French bean, as though they knew they could not stand by themselves, find another way to raise their heads on high: they twine the whole length of their bodies round the poles or the rods which are planted near them; and thus their growth and their fruit are upheld from rotting upon the ground. The ivy, for the same reason, but by another contrivance, climbs up the oak, and sticks close to its sides; and the feeble plant, which we vulgarly call the creeper, that can hardly raise itself three feet high alone, thrusts out its claws at proper distances, fixes them fast in the neighbouring wall or building, and mounts by this means to the tops of the highest houses. What variety of artifice is found here among these feeble vegetables to support themselves!

Yet we believe these plants have no understanding, and mankind are all agreed they have no such thing as sense belonging to them; and we immediately recur to the wisdom of God the Creator, and as-

cribe the contrivance and the honour of it to him alone. It was he, we say, who gave the vine its curling tendrils, and the creeper its hooky claws: it was he instructed the one to bind itself with natural winding cords to the boughs of a stronger tree; and he taught the other, as it were, to nail itself against the wall. It was he shewed the ivy to ascend straight up the oak; and the hop and the lupin, in long spiral lines, to twine round their proper supporters.

Let us inquire now, "What do we mean by such expressions as these?" Truly nothing but this: that God formed the natures of these vegetables in such a manner, as that by certain and appointed rules of mechanical motion, they should grow up and move their bodies and their branches, so as to raise and to uphold themselves and their fruit. Thus the wisdom of God, the great Artificer, is glorified in the vegetable world.

And why should we not give God the Creator the same honour of his wisdom in the animal world also? Why may we not suppose that he has formed the bodies of brute creatures, and all their inward springs of motion, with such exquisite art, as even in their youngest hours, without reasoning and without imitation, to pursue those methods as regularly which are necessary for their life and their defence, by the same laws of motion and the same unthinking powers? This is nature, when God has appointed it. This seems to be the true idea, and the clearest explication of that obscure word, instinct.

If we allow these young animals to perform all their affairs by their own contrivance and sagacity, why do we not ascribe the same sagacity and artifice to vines and ivy, that we do to young sparrows or chickens? The motions of the plants are slower indeed, but as regular and rational as those of the animals; they shew as much design and contrivance, and are as necessary and proper to attain their end.

Besides, if we imagine these little young birds to practise their different forms of motion for their nourishment or defence, by any springs of reason, meaning or design in themselves, do we not ascribe understanding to them a little too soon, and confess their knowledge is much superior to our own, and their reason of more early growth? Do we not make men, or rather angels of them, instead of brute creatures? But if we suppose them to be actuated by the peculiar laws of animal motion, which God the Creator, by a long foresight has established amongst his works, we give him the honour of that early and superior reason, and we adore the Divine Artificer. *Psalm* cxlv. 10. "All thy works shall praise thee, O Lord."

But we are lost among these wonders of thy wisdom! We are ignorant of thy divine and inimitable contrivances! What shall we say to thee, thou All-wise, Creating power! Thy works suprise us: the plants and the brutes puzzle and confound our reasonings: we

gaze at thy workmanship with sacred amazement: thy ways in the kingdom of nature are untraceable, and thy wonders past finding out.

But what will some readers say when they peruse these discourses? Are plants and brutes so very near akin to each other? Creatures which we have always distinguished into the sensible and the senseless! Have birds and beasts no more perception or feeling, knowledge or consciousness, understanding or will, than the herbs, the trees and the flowers! Is the grass of the field as sensible as the animal which eats its? Excuse me here, my friends: I dare assert no such paradoxes. What if some of the early actions of brute creatures are merely the effects of such machinery and instinct as I before described? It does not follow thence, that all the operations of their lives must be ascribed to such a mechanical principle.* Even in human nature, where there is an undoubted principle of sense and reasoning, there are some early actions which seem to be the proper effects of such instinct or mechanism, and are owing to the wondrous divine artifice in the contrivance of their animal bodies, and not to any exercise of their own reasoning powers. How doth the infant hunt after the breast, and take it into its mouth, moving the lips, tongue and palate in the most proper forms for sucking in the milk to nourish it! How does it readily shut the eyes, to cover them from any danger near! How does it raise its cries and wailing aloud for help when it is hurt! These are certainly the effects of instinct in their outward members, as much as the circulation of their blood and the digestion of their food in their bowels and their inward parts.

It is certain, there are several operations in the lives of brute creatures, which seem to be more perfect imitations of reason, and bid fairer for the real effect of a reasoning principle within them, than these early actions which I have mentioned. What strange sub-

* Much ingenious reasoning has been employed on the question, whether brutes are not mere machines, but the inquiry has always appeared to me equally futile and redundant. By the same mode of reasoning, vegetables would take rank as machines; man also, would be considered a mere machine, only on a more exquisite construction: even the world itself would be erected into a machine on a more ample scale which was capable of performing certain evolutions, and producing and nourishing such a variety of organized beings. The idea has even been extended, and the whole universe has been embraced by the epithet, "the grand machine of the universe," says a certain elegant writer: all of which can only be considered as mere figurative expression. If a man makes a loom, he can put it in operation, and make it subservient to the ends for which it was designed: but if that loom could perpetuate its own species, and perform the operations it is intended for, with instinct, or judgment, it would certainly be a machine of superior order, and would require a very discriminating epithet, but it can only subserve its purpose in the hands of the operator, hence it is properly termed a machine. But beings which can act their purpose, independent of an operator, are rather to be considered as agents than machines.

tility and contrivance seem to be found in the actions of dogs and foxes! What artifices appear to be used both by birds and beasts of prey, in order to seize the animals which were appointed for their food, as well as in the weaker creatures, to avoid and escape the devourer! How few are there of the passions, as well as the appetites of human nature, which are not found among several of the brute creatures! What resentment and rage do they discover! What jealousy and fear, what hope and desire, what wondrous instances of love and joy, of gratitude and revenge! What amazing appearances of this nature are observed in birds and beasts of the more docile and domestic kind! Such as puzzle the wisest of philosophers to give a plain, fair, and satisfactory account how all these things can be performed by mechanism, or the mere laws of matter and motion! But how many actions soever may be performed by brute creatures, without any principle of sense or consciousness, reason or reflection, yet these things can never be applied to human nature. It can never be said, that man may be an engine too, that man may be only a finer sort of machine, without a rational and an immortal spirit. And the reason is this. Each of us feel and are conscious within ourselves, that we think, that we reason, that we reflect, that we contrive and design, that we judge and choose with freedom, and determine our own actions: that we can have no stronger principle of assent to any thing than present, immediate, intellectual consciousness. If I am assured of the truth of any inference whatsoever, it is because I am sure of my consciousness of the premises and of my consciousness that I derive this inference from them. My consciousness of these premises therefore is a prior ground of assurance, and the foundation of all my certainty of the inferences. Let a thousand reasons therefore be laid before me, to prove that I am nothing but an engine, my own inward present consciousness of this proposition, that I have thoughts, and that I have reasoning powers, and that I have a will and free choice, is a full evidence to me that these are false reasonings and deceitful arguments: I know and am assured, by what I feel every moment, that I have a spirit within me capable of knowing God, and of honouring or dishonouring my Maker, of choosing good or evil, of practising vice or virtue, and that I hereby am bound to approve myself to the Almighty Being that made and governs me, who will reward me in some future state or other according to my behaviour in this.

And as I can certainly determine this truth, with regard to my own nature, so when I see creatures round about me of the very same species with myself, I justly infer the same truth concerning them also: I conclude with assurance, that they are not mere engines, but have such reasonable and immortal spirits in them, as I find in myself.

It is this inference of similar and equal causes from similar and equal effects that makes a great part in the science of mankind.

Besides, I daily hear men discoursing with me on any subject, and giving as regular and reasonable answers to my inquiries, as I do to theirs; I feel within myself, it is impossible for me to do this without thinking, without the careful exercise of my intellectual and reasoning faculties, superior to all the powers of mechanism; and thence I infer, it is as impossible for them to practice the same discourse of conversation, without the powers of a rational and intelligent spirit, which in its own nature is neither material nor mortal.

Let the question therefore which relates to brute creatures be determined to any side, it does not at all affect the nature, the reason, or the religion of mankind. It is beyond all doubt, that man is a creature which has an intelligent mind to govern the machine of his body: that man has knowledge, and judgment, and free choice; and unless he approve his conduct to the eyes of his Creator and his Judge, in this state of mortality and trial, he exposes himself to the just vengeance of God in his future and immortal state.

It is certain, that the all-wise and all-righteous Governor of intelligent creatures, will not appoint the very same fate and period to the pious and the profane; neither his wisdom, his equity, nor his goodness, will suffer him to deal out the same blessings and the same events in every state of existence, to those who have loved him with all their souls, and those who have hated and blasphemed his name. It is the glory and the intent of the Supreme Ruler of the universe, to make a conspicuous and awful distinction in one world or another, between those who have endeavoured to serve him, and to render his majesty honourable among men, and those who have impiously abused all his favours, ridiculed his thunder, and robbed him of his choicest honours. But if philosophy should fail us here, if it were possible for creatures of such different characters to have nothing in their own natures which was immortal, yet it is a very reasonable thing, that the great Judge of all should prolong their beings beyond this mortal state, that the sons of vice might not go triumphant off the stage of existence, and that the men of virtue might not be always oppressed, nor come to a period of their being, without some testimony of the approbation of the God that made them.

CHAPTER III.

OF METALS, MINERALS, AND OTHER FOSSILS.

1. Among the bodies that remain to be considered, those which seem to bear the nearest resemblance to plants, are fossils, comprehending under the name, all bodies that are dug out of the earth. These have frequently been, for order's sake, divided into three classes: such as are capable of liquefaction: such as are reducible to a calx: and such as are inflammable. Of the first class, are metals: gold, silver, platina, copper, iron, tin, lead, quicksilver. However these differ in other respects, they all agree in the following particulars: that they are heavier than any other bodies yet known; that they are malleable; and that they are capable of liquefaction.

2. It is not improbably supposed, all metals consists of particles so heavy, that they cannot be totally torn asunder or dissipated by fire, or put into so rapid a motion as to inflame. It only separates them so far as not to resist a hard body, which is what we term liquefaction.*

* It becomes a question in natural philosophy, whether one particle of matter is heavier than another. The heaviness of bodies depends on the density of the medium in which they are suspended. The degrees of density are found to be in a cubic ratio, in proportion to the distance from the centre of revolving motion. So making the degree of density in which we live a mean for computation the weight of any body will increase in proportion to its elevation, and decrease in proportion to its depression, from the mean of calculation: but speaking more philosophically, all bodies will be attracted to their centres of gravity, in proportion to their densities and distances.

All metals as well as other bodies, are capable of entering into the airiform state, and of being completely dissipated by various chemical processes, the truth of which has been amply ascertained by numerous recent experiments. Even the hardest substance in nature, which is the diamond, has been completely dissipated and converted into air: there is scarce a known substance which has not been experimented upon with success, and added to the bulk of the atmosphere. The ductility and malleableness of metals are here demonstrated to be mere local characters of their aggregate state. And that the constituent particles are subject to the same laws of attraction and repulsion as those of every other species of matter.

It has already been noticed as an admirable circumstance respecting matter generally, in the alternate states of concretion, and solution, that particles in one instance are capable of entering into the most compact state of union, cleaving to each other with the utmost eagerness, and forming solid bodies: in the other instance meeting with their proper menstruum, they become suspended therein, occupying it at equidistances, and flying from each other as if with aversion, and this is what constitutes the state of fluidity; for all fluids are, matter in

Their malleableness, or bearing to be wrought by the hammer, may spring from the figure of their parts, perhaps oblong or square, which may occasion their cohering so strongly, as not easily to be separated. And it is probable the pores, either of their constituent particles, or of the whole mass, are few and small, which may account for their being so much heavier than any other known bodies.

This is the radical character of metals. The weight of gold to that of glass is as nine to one: and the weight of tin, the lightest of all metals, is to that of gold as seven to nineteen: which considerably surpasses the weight of all stones and other the most solid bodies. Nor is there any body in nature but a metal, that is one third of the weight of gold.

The specific weight of the several metals, and of the granite water and air, stands thus:

Gold,	19636	Iron,	7852
Quicksilver,	14019	Tin,	7321
Lead,	11345	Granite,	3978
Silver,	10535	Water,	1000
Copper,	8843	Air,	$\frac{3}{11}$

3. The nutrition of metals seems to consist only in the accretion of homogeneous parts, which is not improbably supposed to continue, while they lie in their native bed. Many suppose, that they have lain there ever since the flood, if not ever since the creation. Whether they have or not, they seem to grow as long as they remain therein. And after these beds have been emptied by miners, in a

solution: and it is highly presumable that there is not a solitary substance in nature, which has not in nature its proper menstruum: but these important facts may be considered more discriminately. It is notorious that the solidity of all bodies is not equal, but that they vary in degrees of compactness and ponderosity. And by analogous inference, all fluids vary in degrees of suspension and volatility, and these variations and degrees would appear to extend in uniform and corresponding ratios. So that the particles which are capable of entering into the greater degrees of density, and union, in the concrete state; are capable of the greater degrees of solution and rarification in the fluid, airiform state. The proposition would apply of course in an especial manner to metalic substances, which are the most compact and dense of all natural bodies. And this fact, admitting it to be such, would open to our view a strange and astonishing phenomenon; that the metals which are qualified by their extreme density, to occupy the lower regions of the earth; when reduced to the airiform state would naturally take their place in the upper regions of the air. Hence by the known laws of compression and dilatation all the meteorological phenomena would be resolvable into clear physical cause, and effect. For it would seem under this review of the case, that the density of the region which they would occupy, would be in proportion to the space; and this space would be subject to perpetual variations; hence the alternate compression and expansion of the nether strata of the atmosphere, whence proceed winds, storms, lightning, meteors, &c.

time they recruit again. Yea, the earth, or ore of allum will recruit again above ground, if it be exposed to the open air. And so in the forest of Deane the best iron, and in the greatest quantities, is found in the old cinders melted over again.

However, it has long been disputed, whether metals are generated, or were all originally produced at the creation: and whether there be any general seeds of metals, as some suppose antimony to be.* This is indeed a fossil of a very peculiar nature. It is a kind of undetermined, metallic substance, mixed with stony and sulphureous particles, so that it is hard to reduce it to any class. It is found in mines of all metals, but chiefly in silver or lead mines. That in gold mines is counted the best. It has also its own peculiar mines. It lies in clods of several sizes, nearly resembling black-lead, but is full of small shining threads, like needles, brittle as glass. It melts in the fire, though with some difficulty. Its uses are very numerous. It is a medicine of sovereign use in many cases, when warily and properly administered. It is a common ingredient in burning concaves, serving to give the composition a finer texture. It makes a part in bell-metal, in order to render the sound more clear. It is mingled with tin, to make it more hard, as well as of a brighter colour, and in lead, in casting of printers' letters, to render them more smooth or firm. It is also a general help in casting of metals, and especially in casting cannon balls.

4. Gold is either found in small grains in the sand of rivers, (formerly in several of the rivers of Europe) or is dug out of the earth, in small pieces of a tolerable purity. Sometimes it is also found like the ore of other metals, in a mass of earth, stone, or sulphur. In this state it is of all colours, red, white, blackish, making no ostentation of its real value.

The chief properties of gold are, 1. It is the heaviest though not the hardest of bodies. 2. It is the most ductile and malleable of all metals, of which gold beaters and wire drawers give us an abundant proof. But this depends altogether (incomprehensible as it is) on its being free from sulphur. For mix but one grain of sulphur with a thousand of gold; and it is malleable no longer. 3. It is more fixed in the fire than any other metal. Lay a quantity of gold two months in the intensest heat, and when it is taken out, there is no sensible

* All bodies perpetuated in succession from the seed, as vegetables and animals are considered as organized bodies. Metals are ranked among inorganized bodies, or they are considered as bodies formed by accretion. The process of their formation is doubtless carried on daily, and they are unquestionably subject, like every other substance in nature, to the alternate vicissitudes of concretion and dilatation: at one time forming a component of the solid earth, and at another, a component of the liquid air.

diminution of its weight. And yet in the focus of a large burning glass, it volatizes and evaporates. Yea, many thousands of moidores were wholly consumed, others half, or a quarter consumed, by the flames which broke out, during the late earthquake at Lisbon. Gold may likewise by a glass be fused into a sort of calx, and then vitrified. But if the same be fused again with grease, it is restored into gold. 4. It is dissolvable by no menstruum known, but aqua regia or mercury. The basis of aqua regia is sea-salt, the only salt which has any effect on gold. But this has its effect, however applied, whether in a fluid or solid form. 5. It readily and spontaneously attracts and absorbs mercury. But as soon as the mercury enters it, the gold becomes soft like paste. 6. It withstands the violence both of lead and antimony. All metals but gold and silver melted with lead, perish with it, and evaporate: and all but gold, if melted with antimony. Thus melt gold, silver, copper and tin with antimony, and all the rest rise to the top, and are blown off with bellows, but the gold remains behind. Hence antimony is used as the test of gold.

The malleableness or ductility of gold, is beyond all imagination. By exact weighing and computation it has been found, that there are gold leaves, which in some parts of them are scarce 350,000th part of an inch thick. And yet this is a notable thickness in comparison of that of the gold spun on silk in gold-thread. It has been proved that the breadth of these gold plates is only the 96th part of an inch, and in their thickness, the 3072d: so that an ounce of gold is here extended to a surface of 1190 square feet.

How thin must it be when thus extended! In some parts it has been computed, its thickness is only the 3,150,000th part of an inch! And yet with this amazing thinness, it is still a perfect cover for silver: nor can the best eye, or even the best microscope discern the least chasm or discontinuity. Nay, there is not an aperture to admit alcohol of wine, one of the subtlest fluids in nature: no, nor light itself. So closely connected are the particles, notwithstanding their inconceivable thinness.

Silver approaches the nearest to gold in ductility and resisting fire. Like the ore of all other metals, it is found in the earth, under different forms and colours. But it usually affects somewhat of a pointed regular form like crystals. It is never found in sand or grains, as native gold is. It is sometimes ash-coloured, sometimes spotted with red and blue, sometimes of changeable colours, many times almost black.

Although the history of fossils has been diligently cultivated, especially by the moderns, yet it must be owned, that amidst the vast variety of them, there is still room for new inquiries. No wonder

therefore, that among the great variety of salts, ores, and other concretes, new mixtures should daily be discovered. But that among bodies so simple as metals, any should still remain unknown, will appear extraordinary.

Yet so it is: there has been discovered in New Spain, an original metal between gold and silver, the Spaniards call it platina, from the resemblance in colour which it bears to silver. It is of an uniform texture, bright and shining. It takes a fine polish, and does not tarnish nor rust. It is very hard and compact, but extremely brittle, and malleable but in a small degree.

It is found chiefly in small grains, yet not pure, but mixed with a shining black sand. There are likewise usually mixed with it, a few shining particles of a golden colour.

When exposed by itself to the fire, it is extremely hard to melt. It has been kept for two hours in an air furnace, in a heat that would melt cast iron in fifteen minutes, without being either melted or wasted. But when exposed to a proper heat with gold, silver, copper, lead, or tin, it readily melts and incorporates with them. Having been kept in an assay-furnace with lead for three hours, till all the lead was wrought off, it was found remaining at the bottom, without having suffered any alteration or diminution. A piece of it having been put into strong aquafortis, and kept in a sand heat for twelve hours, yet when taken out it was no ways corroded, and was of the same weight as when put in. It has been said to be heavier than gold: but that is a mistake. Its specific gravity is to that of water, as fifteen to one. Yet an equal mixture of gold and platina, was near as heavy as gold itself, being to water as nineteen to one. It appears then, that no known body comes so near gold in fixedness and solidity. If it could be made as ductile as gold it would not easily be distinguished from it.

Platina is likewise found in large, hard masses: these masses are with great labour, reduced into small grains, which are afterwards ground with mercury to extract the gold; and it is not to be brought into fusion by the greatest degree of fire procurable in the ordinary furnaces. It entirely resists the vitriolic acid, which dissolves or corrodes every other known metallic body except gold. Nay, it resists the marine fumes, and the regal cement, so called, from its being supposed to purify gold from all heterogeneous metallic matters. It also resists the force of the vitriolic and nutrous acids, though applied in such a manner as to be capable of perfectly dissolving all other known metallic bodies. It follows from other experiments, that platina contains no gold; for it cannot, any more than the common metallic substances, prevent a small portion of gold mixed with it from being discoverable. It farther appears, that platina, like gold, is not

acted on by the simple acids which dissolve every metallic body besides: that *aquæ regiæ*, the solvents of gold, prove menstrua for platina; and that consequently the common methods for assaying and purifying gold by aqua-fortis, *aquæ regiæ*, or the regal cement, can no longer be depended on: that it differs from gold, in giving no stain to the solid parts of animals, not striking a purple colour with tin, not being revived from its solutions by inflamable spirits, not being totally perceptible by alcaline salts; that in certain circumstances it throws out gold from its solutions; that these properties afford means of distinguishing a small portion of gold mixed with a large one of platina, or a small portion of platina with a large one of gold; and that platina contains no gold excepting the few particles distinguished by the eye. That platina is precipitated from its solutions by the vitriolic acid, and by the metallic substances, which precipitate gold, though scarce totally by any: and that its precipitates resist vitrification, and this perhaps in a more perfect manner than precipitates of gold itself. It is therefore a simple metal of a particular kind, essentially distinct from all those hitherto known, though possessed of some properties generally supposed peculiar to gold. Many of its characters have been already pointed out; others result from combining it with the several metals, with each of which, notwithstanding its resistance to the most intense fires by itself, or with unmetallic additions, it melts perfectly; occasioning remarkable alterations in their colours, texture, and hardness. It melts with equal its weight of each of the metals, with one more readily than with another. With some it becomes fluid, in a moderate fire; but a strong one is requisite for its perfect solution. Compositions of silver, copper, lead, with about one third their weight of platina, which had flowed thin enough to run freely in the mould, and appeared to the eye perfectly mixed, on being digested with aqua-fortis till the menstruum ceased to act, left several grains of platina in their original form. Upon viewing these with a microscope, some appeared to suffer no alteration; others exhibited an infinite number of minute, bright, globular protuberances, as if they had just begun to melt. Platina hardens and stiffens all metals; one more than another, lead the most. In a moderate quantity it diminishes, and in a large one destroys the toughness of all the malleable metals, but communicates some degree of this quality to cast iron. Tin bears much the least, and gold and silver the greatest quantity without the loss of their malleability. A very small portion of platina scarce injures the colour of copper and gold: a larger renders both pale, a far less quantity has less effect on copper than on gold. It debases and darkens, in proportion to its quantity, the colour of the white metals; that of silver much the least, and of lead the most. It in good measure preserves iron and copper from tar-

nishing; scarce alters gold or silver in this respect; makes tin tarnish soon, and lead exceeding quick.

Copper comes next to silver in ductility. Brass is an artificial metal, composed of copper fused with *lapis caliminaris*. Iron is less ductile than any of these, and contains more dross.* It likewise easily rusts, whereas silver seldom rusts, and gold seldom either rusts or cankers. Tin resembles lead,† but is considerably harder and not near so heavy. Indeed it seems to be a sort of imperfect metal, generated of two different seeds, that of silver and that of lead, which makes it a kind of compound of both. And it is sometimes found in silver mines, sometimes in lead mines, though it has also mines of its own. It is the lightest of all metals, very little ductile or elastic, but the most fusible of all. It is scarce dissolvable with acids, but easily mixes with other metals.

Of all the substances concurring to form the terrestrial globe, iron seems to have the greatest share: as it not only abounds in most kinds of stone, but enters greatly into the composition of clay. This may be judged, from the similitude of colour between clay and dry iron ore, from the easy vitrification of clay, from the resemblance of vitrified clay to clinkers of iron, from its deep red colour after calcination, and, lastly, from its yielding pure iron, by being burnt with oil.

Dr. Lister has shewn that stones out of the human bladder, being calcined, iron may be extracted from them by a loadstone. And there is scarce any terrestrial substance either in men, brutes, or plants, which after burning do not exhibit some metallic particles. Dr. Bucher says, that out of brick earth, mixed with any fat or oil, and calcined in the fire, he hath produced iron: for it is only the iron that causes the redness of the bricks: and it can be extracted from them again. Moreover, metals are dissolved by the salts and moisture in the earth, and so mix with the nutricious juices of vegetables; hence it may in some respects be said, that we eat metals with the greatest part of our food.

* The spirit of vitriol being mixed with iron, after fermenting, produces a green vitriol like the natural one. But if for spirit of vitriol, you use oil of vitriol, which is the most acid part of that mineral, there happens immediately a small fermentation, which is quickly over. That fermentation begins again in a few days, under the form of a white smoke, which rises to the surface, and the whole mass of iron turns into a very white pap which smells like common sulphur. When the fermentation is over, the iron, instead of turning into green vitriol, becomes on a sudden white vitriol. Mean time there is on its surface a black dust, which it has thrown up. It seems this would have made it green. For if white vitriol be mingled with this dust, it acquires a green colour.

† White-lead is thin plates of lead dissolved in vinegar. Red-lead is commonly calcined. Black-lead (very improperly so called) is only a chalky kind of earth.

The arbor martis is a germination of iron, resembling a natural plant. The manner of its discovery was this. One poured oil of tartar on iron filings, dissolved in spirit of nitre in a glass. Presently the liquor swelled much, though with little fermentation, and was no sooner at rest, than there arose a sort of branches adhering to the glass, which increased till they covered it all over. And these branches were so perfect, that one might even discover a kind of leaves and flowers thereon. The experiment has since been frequently repeated, and with the same success.

A friend of mine shewed me an experiment of the same kind. In a glass placed over a moderate fire, there was a continual budding of silver, in the form of a branch. When this was clipped off with scissars, and a little crude mercury added, in a small time there arose another branch of true silver, which had sucked in and converted into metallic springs, a considerable portion of the quicksilver. The increment of new silver branches ceased not, as long as the fire was continued and fresh mercury supplied, for the due nutriment of this mineral vegetation. The ingredients were only aquafortis, quicksilver, and a small quantity of silver, far less than you may reap in a small time from these silver sprigs. Yet far more expense is blown away in smoke, then can be recovered from this silver harvest.

Not much unlike this was an experiment made by a gentleman, who kept in a cabinet some pieces of fire-stone from a coalpit, and some large pieces of crude allum stone, such as it was when taken out of the rock. After a time both these had shot out tufts of long and slender fibres: some of which were half an inch long, bended and curled like hairs. And as often as these tufts were wiped off, they sprouted out again.

But both of these fall short of what is related by a curious naturalist. "Having extracted the salts out of a quantity of fern-ashes after the common method, most of the water being evaporated, I had several pounds of salt, most of which being dried, I exposed the rest to the air. Having put it into a large glass, I forgot it for five or six weeks; looking after it then, I was saluted with a pleasing spectacle. The lixivium had deposited a large portion of salt, out of which sprung at a small distance from each other, about forty branches, which exactly resemble fern, putting out many leaves on each side, from one stem. They were of different sizes, but the figures of all were precisely the same. And these artificial vegetables, taking care not to shake them, I preserved for many weeks."

And yet the following account is stranger still. "I mixed equal parts of sal ammoniac and potashes, which were put into a tall glass body, with plenty of volatile salt sublimated. I expected no unusual

appearance from this, having often repeated the operation. Being called out just as the salt began to appear, how was I amazed at my return, to see in the glass head a forest in perspective, so delineated, as scarce to be equalled by the greatest masters. They were a representation of firs, pines, and another sort of tree I have never seen. But of this delightful spectacle I was soon deprived by the sublimation of more salts.

"The next day I related this to Sir Robert Murray. He told me, one Davison, an experienced chemist, at Paris, had frequently shewed him in a glass a great company of firs and pines, full as lively as any can be painted. But in a little time they disappeared. He produced them again at pleasure But herein his operation differed from mine: the substance out of which he raised those shapes was of a more fixed nature; that which afforded mine, was volatile to the highest degree. Again, he could constantly and regularly produce those beautiful representations: whereas mine unexpectedly appeared; nor have I any hope of seeing them again."

Sal ammoniac is made of the soot arising from the dung of four-footed animals, as sheep, oxen, and camels, so long as they feed only on green vegetables. This dung is collected in the four first months of the year, when all these feed on fresh spring grass. This, in Egypt, is a kind of trefoil or clover. But when the cattle are fed on hay, and the camels on bruised date-kernels, their excrements are not fit for this purpose.

The nitre of Egypt was well known to the ancients. It is produced in two lakes near Memphis. One of them is four or five leagues long and one league broad: the other, three leagues long, and one and a half broad. In both, the nitre is covered by a foot or two of water. They cut it up with long iron bars, sharp at the end. And what is taken away, is replaced in one or two years, by new nitre, coming out of the earth.

5. If iron in melting be carefully purged from its dross, drawn into plates, and plunged red-hot into cold water, it grows harder and is termed steel. But it is considerably softened again, if it is put into the fire, and afterward left to cool gradually in the air.

6. Quicksilver differs from all metals, in that it is naturally liquid. Its properties are, 1. It is the heaviest of all bodies, but gold and platina. 2. It is the most fluid of all. The particles even of water, do not divide so easily as those of quicksilver: they have hardly any cohesion. 3. Of all bodies it is divisible in to the minutest parts. Being on the fire, it resolves into an almost invisible vapour. But let it be divided ever so much, it still retains its nature. For the vapours of distilled quicksilver, received in water or on moist leather, become pure quicksilver. And if it be mixed with lead or other

bodies, in order to be fixed, it is easily by fire separated from them again, and reduced to its ancient form. 4. It is extremely volatile, being convertible into a fume, even in a sand-heat. 5. Of all fluids it is in equal circumstances the coldest and the hottest. This depends on its weight; for the heat and cold of all bodies, is (cæteris paribus) as their weight. 6. It is dissolvable by almost all acids, but vinegar. And hereby we discover, if it be sophisticated with lead. Rub it in a mortar with vinegar. If it be mixed with lead it grows sweetish: if with copper it turns greenish or bluish. If there be no adulteration, the quicksilver and vinegar will both remain as before. 7. It is the most simple of all bodies, but gold and platina. 8. It has no acidity at all, nor does it corrode any body.

But it may be observed of metals in general, there is a great uncertainty and inconstancy in the metallic and mineral kingdoms, both as to colour, figure and situation. A marcasite, for instance, may have the colour of gold and silver, and yet afford nothing but a little vitriol and sulphur: while what is only a pebble in appearance, may contain real gold.

It is common also to find the same metal shot into many different forms, as well as to find different kinds of metal of the same form. There is the same uncertainty as to their place. Sometimes they are found in the perpendicular fissures of the strata, sometimes interspersed in the substance of them; and the same metals in strata of very different natures. They are likewise frequently intermixed with each other; so that we seldom find any of them pure and simple but copper and iron, gold and copper, silver and lead, tin and lead in one mass: yea, sometimes all fix together.

What distinguishes them from all other bodies, as well as from each other, is their heaviness: each metal having its peculiar weight, which no art can imitate.

But who can reckon the various ways, wherein metals are useful to mankind? Without these we could have nothing of culture or civility; no tillage or agriculture; no reaping or mowing, no ploughing or digging, no pruning or grafting, no mechanic arts or trades, no vessels or utensils of household stuff, no convenient houses or edifices, no shipping or navigation. What a barbarous and sordid life, we must necessarily have lived, the Indians in the northern parts of America, are a clear demonstration.

And it is remarkable, that those which are of most necessary use, as iron and lead, are the most plentiful. Those which may better be spared, are more rare. And by this very circumstance they are qualified to be made the common measure and standard of the value of other commodities, and to serve for money, to which use they have been employed by all civilized nations in all ages.

All metals are liable to rust. Gold itself rusts, if exposed to the fumes of sea-salt. The great instrument in producing rust is water: air, only by the water it contains. Hence in dry air metals do not rust; neither, if they are well oiled: water not being able to penetrate oil. Rust is only the metal under another form. Accordingly rust of copper may be turned into copper again. Iron, if not preserved from the air by paint, will in time turn wholly into rust.

7. Mines in general are cavities, within the earth, containing substances of various kinds. These the miners term *loads*: if metallic, they are said to be *alive*; if not, to be *dead bodies*. In Cornwall and Devonshire the loads always run from east to west. Mines seem to be, or to have been channels of waters within the earth, and have branches opening into them in all directions. Most mines have streams running through them: where they have not, probably the water has changed its course. The springs in these parts are always hard, abounding either with stony or sulphureo-saline particles.—These particles are either of a vitriolic or an arsenical nature. The first concretes into white cubes, resembling silver, the second into yellow ones resembling gold. Both these are by the miners termed mundic.

8. Mundic is variously coloured on the outside with blue, green, purple, gold, silver, brass, and copper colours. But within it is either of the colour of silver, of brass, or gold colour, or brown. The other colours are no more than a thin film or sediment, which water, variously impregnated, deposits upon the surface.

There are few copper loads, if any, but have this semi-metal (which is a kind of wild mock copper) attending upon them. Therefore, in searching for copper, it is reckoned a great encouragement to meet with mundic. The mundic does not intimately incorporate itself with the ore of copper; for copper in its mineral state, being naturally of a close consistence, repels the mundic, which is therefore easily separated from the ore.

Cornish waters are infected by mundic, more or less, according to the quantity which they pass through, and the disposition of the mundic, either to retain or to communicate the noxious particles of which it consists. Arsenic, sulphur, vitriol, and mercury, are the constituents of mundic, yet these pernicious ingredients are so bridled and detained by their mutual action and re-action, and by mixing with other minerals, that the water is not poisonous, generally speaking, even in the mine where it proceeds directly from the mundic.

Mundic resembles plants, animals, mouldings, carvings, and sundry more varieties, too numerous to insert. Shall we attribute this to a plastic power superintending the congress of fossils, and sporting itself with such representations? Or shall we rather say, that the

great power which contrived and made all things, needing no delegate, artfully throws the flexile liquid materials of the fossil kingdom into various figures, to draw the attention of mankind to his works, and thence lead them to the acknowledgment, and adoration of an intelligent being, inexhaustibly wise, good, and glorious? Doubtless these are the works of that same lover of shape, colour, and uniformity that paints the peacock's train, that veins the onyx, that streaks the zebra: it is the same hand whose traces we may discover even among the meanest and most obscure fossils. God loves symmetry, gracefulness, elegance, and variety, and distributes them for his complacency as well as glory; limits them not to plants, and animals, and open day-light, but like a great master habitually imparts them to all his works, though in the deepest ocean, and in the most secret parts of the earth.

9. Although fissures are the natural result of a moistened and mixed congeries of matter, passing by approximation of parts into a state of solidity, we are by no means to conclude them useless, or the works of chance. No, the great Architect, who contrived the whole, determined the several parts of his scheme so to operate, as that one useful effect should become the beneficial cause of another. Hence it happens, that matter could not contract itself into solid large masses, without leaving fissures between them: and yet the fissures are as necessary and useful as the strata through which they pass. These are the drains which carry off the redundant moisture from the earth, which but for them, would be too full of fens and bogs for animals to live, or plants to thrive on. Through these fissures the rain which sinks beneath the channels of rivers, not having the advantage of that conveyance above ground, returns into the sea, bringing the salts and mineral juices of the earth into the ocean, enabling it to supply the firmament with proper and sufficient moisture, and preserving that vast body, the sea, wholesome, fit for fish to live in, and sailors to navigate.

In these fissures the several ingredients which form the richest loads, by the continual passing of waters, and the menstrua of metals, are educed out of the adjacent strata, collected and conveniently lodged in a narrow channel, much to the advantage of those who search for and pursue them. For if minerals were more dispersed, and scattered thinly in the body of the strata, the trouble of finding and getting at metals, those necessary instruments of art and commerce, and the ornaments of life, would be endless, and the expense of procuring, would exceed the value of the acquisition: without these, neither metals, marbles, salts, earths, nor stones, could be so easily or in such plenty, provided, as is necessary for the use of man.

Earth is certainly the general food and stamen of all bodies, yet

we know of itself it can do nothing: it must be connected by a cement, or it cannot form stone; it must be softened and attenuated by moisture and warmth, or it cannot enter into the alimentary vessels of plants and animals. The parts of earth which constitute the solids of any plants are exceeding fine, and the common mass in which we plant trees, is for the most part gravel, clay, and sand, which promote vegetation, but are too gross to enter into, and become the constituents parts of them. Water must therefore be considered as the vehicle of more solid nourishment, and the parent of the fluids: the earths, salts, and oils, are the great instruments of the increase of solids. To trace fertility a little farther; when the earth is softened and diluted heat rarefies and evaporates the mixture; the salts contained and dissolved, are always active and promote motion; the elasticity of the air quickens and continues it: the oils supple the passages, of which some are fitted to secrete, arrest and deposit the nutritious particles as they pass; some adapted (by the same secret hand, which conducts every part of the operation) to throw off the redundant moisture by perspiration: the earthy mixture composes the hard and solid parts, and the genial, little atmosphere of every plant gives spirit, colour, odour and taste. Herbs and fruits being thus fed and matured, make the earth they contain better prepared to pass into the still more curious and highly organized parts of animals. It is easy to see that this is rather a detail of the several materials, and well known instruments, conducing to fertility, than the cause. Fertility is owing to the concert, fitness and agreement of all these, with some volatile active principle, of which we know nothing at all. But whence that agreement results, how the materials ferment, replace, connect, and invigorate one another, how the vessels choose and refuse, (if I may so say) in order to produce the fertility desired, is known only to the infinitely wise Disposer of all things, ever attentive to the nurture and support of what he has created. But to whatever cause the fertility of earth is to be assigned, earth it must be owned is a most fruitful universal element. Animals, plants, metals and stones arise out of it, and return to it again; there, as it were to receive a new existence, and form new combinations, the ruins and dissolutions of one sort affording more and more materials for the production of others.

In stones and metals, we admire the continuity, hardness and lustre of earth; in plants, the rarity, softness, colours and odours: in animals, the flesh, the bone, and an infinite number of fluids, in which this supple element can take place: but the greatest wonder is, that earth is capable of being subtalized to such an exquisite degree, as by uniting and communicating with spirit, to perform all animal functions given it in charge by the soul. This is the highest and utmost

refinement, which in this state of being, earth is capable of; but that it may be still farther refined, in order to be qualified for a future, incorruptible, and more glorious state, is one of the greatest truths which we owe to revelation.

10. To the second class of fossils belong those which are reduced by fire to a calx. Such are, 1. Salts, all fossils which whether they have a salt taste or no, are soluble in water. Common salt is heavier than water, and if quite pure, melts when left in the open air. If the water it is dissolved in be boiled and evaporated, it remains in the bottom of the vessel. It is well known to preserve flesh from putrefaction, and to be with great difficulty dissolved by fire. Probably it is composed of pointed particles, which fix in the pores of flesh, and by reason of their figure are easily divided by water, though not by fire. It ever comes purer out of the fire. Yet it will fuse in a very intense heat.

All salt dissolves by moisture: but moisture only dissolves a certain quantity. Yet when it is impregnated with any salt, as much as it can bear, it will still dissolve a considerable quantity of another kind of salt. It seems, the particles of this, being of different figures, insinuate into the remaining vacuities. Thus when a cup of water will dissolve no more common salt, allum will dissolve in it.—And when it will dissolve no more allum, saltpetre will dissolve, and after that, sal ammoniac.

The most remarkable salt mines in the world, are in the village Willisca, five leagues from Cracow in Poland. They were first discovered above 500 years ago, in the year 1251. Their depth and capacity are surprising. They contain a kind of subterranean republic, which has its laws, polity, carriages, and public roads for the horses which are kept there, to draw the salt to the mouth of the quarry. These horses after once they are down, never see the light of the day again. But the men take frequent occasions of breathing the upper air. When a stranger comes to the bottom of this abyss, where so many people seem interred alive, he is surprised with a long series of lofty vaults, sustained by huge pillars, which being all rock salt, appear by the light of flambeaux, that are continally burning, as so many crystals, or precious stones of various colours.

11. To this class, secondly, belong STONES, which are hard, rigid, void of taste, reducible to dust by the hammer, and into a calx by fire. It is probable, that stones, like salts and most fossils, are generated from a fluid, which gradually hardens into stone, by the evaporation of its finer parts.

Mr. Tournefort observed, that in the famous labyrinth of Crete, several persons had engraven their names in the living rock, of which its walls are formed; and that the letters so engraven, instead of be-

ing hollow, as they were at first, stood out from the surface of the rock. This can no otherwise be accounted for, than by supposing the cavities of the letters filled insensibly, with matter issuing from the substance of the rock, even in more abundance than was needful to fill those cavities. Thus is the wound of a knife healed up, much as the fracture of a bone is consolidated, by a callus formed of the extravasated nutritious juice, which rises above the surface of the bone. Such calluses have been observed to be formed on other stones, which were reunited after they had been accidentally broken. Hence it is manifest, that stones grow in the quarry, and consequently are fed; and that the same juice, which nourishes them, serves to rejoin their parts when broken. There is then no room to doubt, that they are organized, and draw their nutritious juice from the earth, which is first filtrated and prepared in the surface of the stone, and thence conveyed to all the other parts.

Doubtless the juice which filled the cavities of those letters was brought thither from the root of the rock, which grew as corals do, or sea mushrooms, which every one allows to grow: and yet they are true stones.

Indeed there are some species of stones, whose generation can no otherwise be accounted for, than by supposing them to come from a kind of seeds, which contain their organized parts in miniature. But many sorts of stones were once fluid; witness the various foreign bodies found therein.

That even pebble stones grow, may be proved to a demonstration, by an easy experiment. Weigh a quantity of pebbles and bury them in the earth. After a time dig them up, and on weighing them again, you will find they have gained a very considerable addition.

The vegetable mould or surface of the earth, is made up of sands, clays, marls, loams, rotten stalks, and leaves of herbs, serving both as a proper bed and covering, and as a receptacle and conductor of moisture to the roots of trees and plants. Sands and pebbles may be considered as drains, for carrying off the redundant moisture, to places where it may be ready to supply the place of what is continually rising in exhalations. But lest the strata of sand should be too thick, small ones of clay are often placed between, to prevent the moisture from departing too far from where it may be of use. And lest these thin partitions of clay should let the particles of sand insinuate into them, and thereby let the moisture pass through, thin crusts of a ferrugineous substance are placed above and beneath each of these clayey strata: by which means the clay and sand are effectually kept asunder.

Supposing some stones are organized vegetables, and are produced from seed, yet most sorts of stones seem to be unorganized vegeta-

bles. Other vegetables grow by a solution of salts, attracted into their vessels. Most stones grow by an accretion of salts, which often shoot into regular figures. This appears by the formation of crystals upon the Alps. And that stones are formed by the simple accretion of salts, appears from the tartar on the inside of a claret vessel; and still more clearly, from the formation of a stone in the human body. The air is in many places impregnated with such salts or stony particles: and these ascending from the cavities of the earth, may petrify wood. In this case the petrifying quality is not originally, either in the earth or the water: but in the rising steams impregnated with saline or stony particles.

12. Many waters are generally supposed to turn other bodies into stone. This is ascribed to the lake Loghmond in Scotland, and Lough-Neagh in Ireland. But it is a mistake. There is not in reality any such transmutation in those bodies. Only the stony particles floating in the water, lodge in the pores, or on the surface of them. Petrifactions therefore are nothing more than incrustations of stony particles, which surround and partly insinuate into the bodies immersed.

With regard to Lough-Neagh, some think the petrifying quality, to be not only in the water, but in the adjacent soil. Many pieces of petrified wood are thrown up daily, in breaking up new ground, which that water never touched. They are often found two miles from the Lough, in great numbers, and deep in the ground, altogether like the Lough-Neagh stones. That these were once wood is certain. They burn clear, and may be cut with a knife, though not so easily as other wood.

Petrifying springs are impregnated, some with particles of stones, others with serrugineous and vitriolic particles. When the stony ones drop on wood, or other vegetables, they coagulate upon it, and by degrees cover it with a stony coat. If this be broke before the wood is rotted away, you find it in the heart of the stone. If the wood is rotted, you will find a cavity in the stone; but this also in time will be filled up with stony particles. Sometimes indeed these waters penetrate the pores of the wood, fill them up with their stony particles, and by their burning quality proceeding from lime-stone, destroy the wood, and assume the shape of the plant.

Metallic particles mostly act, by insinuating into the pores of wood or other vegetables, without increasing their bulk, or altering their texture, though they greatly increase their weight. Such is the petrified wood in and near Lough-Neagh. It does not shew any outward addition of matter, and preserves the grain of wood. All the alteration is in the weight and closeness, by the mineral particles pervading and filling the pores.

That there are mines near the Lough, we may gather from the great quantity of iron-stones found on its shores, and from the yellowish ochre and clay in many places near it. Now, whatever springs run through these, will be impregnated with metallic particles. And if they rise in the middle of a river or lake, and in their course meet with wood or other vegetables, these particles will insinuate and lodge themselves in their pores, and by degrees turn them into stone.

That such springs are under this lake, appears from hence, that in the great frost, 1740, though the lake was frozen over, so as to bear men on horseback, yet several circular spots remained unfrozen.—Hence it appears, that this petrific quality is not in all parts of the lake, but here and there only. As to the trees which are found petrified and buried at a small distance from the lake, probably it was broader once than it is now, so that what was then under water, is now dry land. If so these trees might have been petrified in the part which was then overflowed, though it is now dry.

13. It is certain, that water impregnated with metallic particles, when falling on wood or other vegetables, will coagulate upon it, as was observed above, and cover it with a metallic coat. It is also certain, that the vegetables included therein, are gradually destroyed, till the same matter which first formed the crust, takes up the whole space which they occupied before. But it is not only wood and other vegetables, which are capable of being thus acted upon, first crusted over and then destroyed. A shovel of iron some years since, lying in the water, in the county of Wicklow, in Ireland, was observed to be incrusted with copper, which gave occasion to an important discovery. A gentleman, who visited the place on purpose to examine the truth of what was commonly reported, observes, "I saw the iron bars impregnated with copper. I was an eye witness to the change in all its progress: and so were thousands beside. I saw the masons laying a chain of new stone troughs, for the copper water to run through. I saw the men also laying the iron bars on wooden rafters, in those troughs. I saw the iron bars lifted up out of some troughs, where they had lain from one to eight months: and saw them incrusted over with copper, and corroded more or less, (some of them to very thin plates) according to the time they had lain in the water. I saw some of the troughs emptied, wherein the bars were wholly dissolved: and the labourers were throwing up with shovels the copper, which lay on the stones in the bottom of them. It was like mud, as it lay wet on the stones in the bottom of them. It was like mud, as it lay wet in the heap, but became dust as it dried. I also saw several pieces of copper, which had been made out of their copper-mud.

"This water is supposed to flow over a vein of copper in the neighbouring mountain. It is of a sharp, acid taste, and of a blue colour. It is received and collected in those troughs, wherein the iron bars were placed: which after lying in the water, often not above three months, are entirely consumed: then at the bottom of the troughs, a quantity of copper is found, in the form of coarse sand. And it is remarkable, that there is a greater quantity of this copper, than there was of iron.

"But by what principle is this effect produced? In order to discover this I made the following experiments.

"1. Some small iron nails put into the water, were in four minutes covered with a substance of a copper colour. And during that time the nails gained four grains in weight. The water had the very same effect on silver and tin, but not on gold. Hence we observe, the colour and increase of weight were owing to the adhesion of the particles of the matter dissolved in the water by an acid, which could not penetrate gold.

"2. In order to determine the quantity and quality of this matter, I put two drachms of small iron nails into three ounces of the water. After they had lain therein four and twenty hours, I found the surface of the water covered with a thick scum, exactly like that which covers a chalybeate spaw. I observed, likewise, it had lost the blue colour, and sharp, vitriolic state. It was quite transparent, and at the bottom lay a brown powder, which when dried, weighed fourteen grains. This powder, melted without any flux, produced twelve grains of pure copper. The nails also (which had lost eight grains) were in several places covered with a solid lamina of pure copper. The water being afterward filtrated and evaporated, afforded a pure green vitriol.

"3. From the spring water treated in the same manner, I obtained a blue vitriol, the basis of which is copper. From all these experiments it appears, that a mineral acid is the active principle in this water, which being diffused through the copper ore, unites itself with that metal, and forms a vitriol. This is dissolved by the water, and remains suspended therein, till it meets with the iron in the trough, and by which it is more strongly attracted than by the copper.—Therefore it quits the copper, corrodes the iron, and changes it into a vitriol, which is again dissolved and carried off in the stream.—Meantime the copper, deserted by its acid, falls by its specific gravity to the bottom of the trough.

"It appears then upon the whole, that this admirable process of nature, whereby one metal seems to be turned into another, is no more than a simple precipitation of the copper, by means of them."

In the Lower Egypt, there is a vast sandy desert, called the Desert of St. Macarius. One large plain herein is called by a name which signifies, *The sea without water*. This is strewed over with limbs of trees which are entirely petrified: very probably by means of the nitre, with which this whole country abounds.

The change of wood into stone is not the only wonder here. The sand is also changed into eagle stones. These stones are found two or three fingers breadth beneath the surface of the earth, in little mines, some paces long and broad, about half a mile from each other. It is thought that in these places, there oozes out of the earth, a sort of metallic matter, which ferments with the burning sand, and in fermenting assumes some kind of roundish figure, and attaches to itself more and coarser sand. Afterward it hardens by degrees, and grows black through the heat of the sun.

The eagle-stone when in the mine is soft and brittle as an egg, and of a bright yellow or violet colour, but after being exposed to the air, it turns brown or black, and hardens gradually. Likewise after a few days, most of these stones, will, if struck, sound like little bells.

Not far off is a vast heap of sand, which they call the Eagle-stone Hill, because it is covered over with great rocks of the very same matter whereof the small eagle-stones are formed.

But what shall we judge of those petrified shells, which have been dug up in many places? Some indeed are not petrified. Near Reading, in Berkshire, for succeeding generations, a continued body of oyster-shells have been found through the circumference of five or six acres of ground. Beneath is a hard rocky chalk, on which the shells lie in a bed of green sand, about two feet thick. Above are various strata for at least eighteen feet. The shells are so brittle, that in digging, one of the valves will frequently drop from its fellow. But several are dug out entire; nay, some double oysters, with all their valves united.

In a quarry at the east end of Broughton, in Lincolnshire, there is a clay under the stone, in which are numberless fragments of the shells of shell-fish of various kinds. And there are sometimes found whole shell-fish, with their shells on, in their natural colours, only bruised and broken, and some squeezed flat by the weight of earth, which was cast upon them at the deluge.

There is another quarry, south of the town, of a blue, hard stone, (probably a pure clay in some antediluvian lake) in which are numberless shell-fish of various sorts, but so united to the stone, that it is hard to get them out whole. They are all in the surface of the quarry, within a foot of the top. On the surface there are many shell-fish, half in the stone, half out. That part which is within the

quarry is whole, but is a hard stone. That which is without, is all consumed, but a little of the edges, which are plain shell.

Some of the shell-fish in this quarry are half open, and filled with the matter of the bed on which they lie. Some of them are broken, others bruised: the edge of one fish is sometimes thrust into the sides of another. One shell of some is thrust half way over the other, and so they are petrified together.

Among these there are several great horse-muscles, such as breed in rivers and ponds. And in the fields and stones near Bramby and Frodingham is found a sort of fish bending like a ram's horn, and creased like one on the outside. The bed wherein, it seems, this fish bred, is about a foot thick: in which are millions of the fish, sticking half within the stone, half without. And this shell being extremely durable, even the part sticking out, is not consumed, as it usually is in others, but remains whole and entire.

14. From stone burnt to dust arises lime, which has this remarkable property, that if cold water be poured upon it, it presently heats and boils up. In order to account for this, some have supposed, that some subtle matter is lodged in the pores of the lime, (perhaps many of those particles of fire whereby the stone was reduced to dust) which when the water insinuates into those pores, occasions the same kind of ebullition, as if it was poured on any other burning substance.

15. Most precious stones are transparent, and strike the eye with vivid and various colours. Probably they were once fluid bodies, which while in that state were mixed with metallic or mineral juices. Their transparency likewise makes this probable, and so does their outward configuration. For many bodies hardening into solids shoot into crystals, just as is observed of several kinds of precious stones: and to this their inward structure answers. For in many we may observe the thin plates or coats one over the other, just as we see in those mineral substances, which were once fluid. Their colours might be owing to some mineral juice or exhalation, which tinctured them before their pores were fully closed. This is the more probable, because many gems lose their colour if they lie long in the fire: and because, generally, coloured gems are found over metallic or mineral veins.

Dr. Boerhaave takes crystal to be the basis of all precious stones, which assume this or that colour, from the metallic or mineral steams mixed with the primitive crystalline matter. Bow how is crystal itself formed? An Italian writer gives a particular account of this. In the Val Sabbia, says he, I observed some parts of a meadow bare of all herbs. Here, and no where else thereabouts, the crystals are generated. And whenever there is a serene and dewy sky, if all the crystals that can be found over night, are taken away, others will be

found in the same place in the morning. Having observed, there is no sign of any mineral steam near, I conclude they are produced by steams of nitre. These may at the same time hinder vegetation in those places, and coagulate the dew that falls thereon. As nitre is the natural coagulum of water, so it ever retains its sexangular figure. The largest crystals known were found in the mountains of Grimiule, between vast strata of stones. The biggest of them was near three feet in length, and little less in circumference. It weighed two hundred and fifty pounds; others weighed less and less, to those of ten pounds, which were the smallest there. They were of the same figure; sexangular columns, terminated by sexangular pyramids at one end, and at the other fixed to the rock. They were in general perfectly clear throughout, but in some the base was foul, in others the point.

If a solution of alum is permitted to crystallize quietly, it shoots into planes of eight, six, four and three sides. But beside this, particles when excited to action by a certain degree of heat, arrange themselves into regular and delightful star-like figures of different sizes. Many of these have long streaming tails, and resemble comets. Others shoot into an infinite number of parallel lines, beautiful beyond description. These configurations are no less constant in their forms, than the crystals on which they grow. And they are equally transparent, but the figures produced are so extremely different, that every considerate observer must judge them to be owing to some very different property in nature. But what property? Who can determine? Indeed how little do we know of the most common things! The very elements that surround us, the fire, the water, the air we breathe, the earth we tread upon, have many properties beyond our senses to reach, or our understanding to comprehend.

Dr. Borlase ranges crystal itself and all gems under the head of spar, which, says he, are only finer and purer substances, of the spar-kind.

All spar has been in a state of fluidity. In some are found straws and other light bodies. Yet time adds nothing to their firmness: but they are as hard when first consolidated, as ever they will be. But why do we find no spars in their fluid state? Because while the matter of them remains incorporated with the water, it is not to be distinguished from it, and as soon as it is deserted by the water, wherein it swims, it commences stone. It is by water that the sparry atoms are washed out of their repositories, and are collected into a transparent or opaque juice. As soon as the redundant water is drained off or evaporated, the stony parts accede to a closer union. They are assisted therein, either by cold compressing the parts, or by sudden evaporating heat. Thus the stone is formed, so much water rest-

ing in the pores as is necessary to fix it into a consistency. Hence may arise some queries.

1. Whether spar is not the universal gluten of stones distinguished from each other, by various mixtures of earthy, mineral, or metallic particles, but all united by the sparry liquor? Perhaps there is scarce any sand, stone, or ore, which either by the naked eye or glasses, may not be discerned to have a portion of spar, clearer or opaque, in its composition.

2. Whether these and all other sorts of stones are not continually forming in the earth?

3. Whether there are not quarries of stone, which, when left unwrought for a considerable time, yield a fresh supply of stone, in those channels, which had been before thoroughly cleared?

A very peculiar kind of precious stone is what is termed a turquois. It is of the opaque kind, and commonly of a beautiful blue colour. And yet it has lately been made very probable, that these shining stones are originally no other than the bones of animals.* In the French mines they are frequently found in the figure of teeth, bones of the legs, &c. And turquoises half formed, are composed of laminæ, like those of bones, between which petrifying juice insinuating, binds them close together. And the more imperfect the stones are, the more distinguishable are the different directions of the fibres and their laminæ, and the nearer resemblance they bear to fractured bones.

The blue turquois, is indeed no other than fossil bone, or ivory saturated with copper dissolved in an alkaline menstruum; the green turquois is the same substance, intimately penetrated by a cupreous matter dissolved in an acid menstruum.

16. The loadstone is found in iron mines, and resembles iron both in weight and colour. Its most remarkable properties are, turning to the poles, and attracting iron. As to the former, when it moves without hindrance, it constantly turns one end to the north, and the other to the south: only declining a little to the east or west. If two loadstones are brought within a certain distance of each other, that part of the one which is toward the north pole of the earth, recedes from that part of the other which respects the same pole. But it accedes to it, if the southern pole of the one, be turned toward the south pole of the other. The needle touched with the loadstone, when on this side the equinoctial line, has its north point bending

* The Turquois is now generally considered as the tooth of some animal penetrated with the blue calx of copper; it loses its colour when heated; it is of a lamellar texture and susceptible of a fine polish; its specific gravity 2.5 to 2.988. Some are of a fine deep blue colour. It is generally found in Persia and Languedoc.

downward; on the other side, its south point: under the line, it turns any way, and is of no use.

As to its attractive power, it not only sustains another load stone, (provided the north pole of the one be opposed to the south pole of the other) but iron also. Likewise if steel-dust be laid upon a loadstone, it will so dispose itself, as to direct its particles straight to the poles, whence they will be moved round by little and little till they are parallel to the axis of the loadstone. It communicates its virtue to iron; and if it be armed with (that is fixed in) iron, its force is greatly increased. It looses its force either by fire, or by letting two loadstones lie together, with the north pole of one opposed to the north, or the south pole of one to the south of the other. These plain phænomena of the loadstone we know: the cause of them we know not.

From late observations it appears, that the loadstone is a true iron ore, and is sometimes found in very large pieces, half loadstone, half common ore. In every one, 1. There are two poles, one pointing north, the other south; and if it be divided into ever so many pieces, the two poles will be found in each piece. 2. If two loadstones be spherical, one will conform itself to the other, as either would do to the earth, and will then approach each other: whereas in the contrary position, they recede from each other. 3. Iron receives virtue, either by touching, or by being brought near the stone: and that variously, according to the various parts of it which it touches. 4. The longer the iron touches the stone, the longer it retains the virtue. 5. Steel receives this virtue better than iron. 6. In these parts the south pole of a loadstone lifts more iron than the north pole. 7. A plate of iron interposed hinders the operation of the loadstone; but no other body; no, not glass itself. 8. A touched wire, if bent round in a ring, quite loses its virtue. But though bending thus destroys its virtue by day, it will not destroy it in the evening. Where is the philosopher in the world, who can account for this? 9. Loadstones without any known cause, act sometimes at a greater distance than at other times. That of the royal society will keep a key suspended to another, sometimes at the height of ten feet, sometimes not above four. As strange as it is, the variation of the needle is different at different times of the day. 10. If a touched wire be split, the poles are sometimes changed (as in a split loadstone). And yet sometimes one half retains the same poles, and the other half has them changed. 11. Touch a wire from end to end with the same pole of the loadstone, and the end first touched turns contrary to the pole that touched it. But touch it again from end to end with the other pole of the stone, and it will turn just the contrary way. 12.

Touch a wire in the middle with one pole of the stone, and the pole of the wire will be in that place: the two ends will be the other pole. 13. The poles of a small loadstone may presently be changed, by applying them to the opposite poles of a large one. 14. Iron bars which stand long in an erect position, grow permanently magnetical; the lower end of them being the north pole, and the upper the south pole. 15. The same effect follows, if you only hold them perpendicularly: but if you invert them, the poles will shift their places. 16. Fire, which deprives a loadstone of its attractive virtue, soon gives verticity to a bar of iron, if it be heated red hot, and then cooled in an erect posture, or directly north and south. 17. A piece of English oker, thus heated and cooled, acquires the same verticity. 18. The verticity thus acquired by a bar of iron, is destroyed by two or three smart blows on the middle of it. 19. Either a piece of iron or a loadstone being laid on a cork that swims freely in the water, which ever of the two is held in the hand, the other will be drawn to it. This proves that the iron attracts the stone, just as much as it is attracted by it. 20. Draw a knife leisurely from the handle to the point over one of the poles of a loadstone, and it acquires a strong magnetic virtue. But this is immediately lost, if you draw it over the same pole from the point to the handle. Lastly, a loadstone acts with as great force in vacuo, as in the open air.

The chief laws of megnetism are these: 1. The loadstone has both an attractive and a directive power: iron touched by it has only the former. 2. Iron seems to consist almost wholly of attractive particles, loadstones of attractive and directive together, probably mixed with heterogeneous matter, as not having been purged by fire like iron. And hence iron when touched, will lift up a much greater weight than the loadstone that touched it. 3. The attractive power of armed loadstones is, cæteris paribus, as their surfaces. 4. Both poles of the loadstone equally attract the needle till it is touched. Then it is that one pole begins to attract one end and repel the other. But even the repelling pole will attract upon contact, or at a very small distance. But how odd are the following experiments? I cut a piece, says Dr. Knight, of a loadstone, in an oblong square. In this I placed the magnetic virtue in such a manner, that the two opposite ends were both south poles, and the middle quite round was a north pole. I made the two opposite ends of another stone, north poles, the opposite side south poles. An irregular stone had two broad, flat surfaces opposite to each other. I made half of each of these surfaces a north pole, and the other half a south pole. So that the north pole of one surface was opposite to the south pole of the other. I took a stone that had a grain very apparent running the lengthways of it. At one

end of it I placed a north pole, surrounded by a south : at the other a south surrounded by a north pole : so that the edges of each surface had a different pole from that which occupied the middle.

Many varieties of this kind might easily be devised. But these examples are sufficient to shew, how manageable the magnetic virtue is, with respect to its direction ; and how defective all the hypotheses are, which are brought to account for the phænomena of the load-stone.

Mr. Howard sailed to Barbadoes in company with an other ship, commanded by one Groston. Suddenly a terrible clap of thunder broke Groston's fore-mast, and did some damage to his rigging. When the noise was past, he was surprised to see Mr. Groston's ship steering directly homeward. He tacked and stood after him, and found, that Mr. Groston did indeed steer by the right point of the compass, but that the card was turned round, the north and south point having changed places. If he set it right with his finger, as soon as it was at liberty, it returned to its former posture. And on examination, he found every compass in the ship had undergone the same change.

An odd discovery has been lately made, that not only iron, as has been generally thought, but brass too, by being hammered and properly touched, will contract a true magnetic virtue. And perhaps it will be hereafter discovered, that other metals may receive the same.

Before closing this article, it may be proper to observe, first, The peculiar qualities wherewith some other stones are endued ; and secondly, the remarkable uses they are of to us. As to the former, we may observe, 1. The colour. The carbuncle and ruby shine with red, the sapphire with blue, the emerald with green, the topaz with a yellow or gold colour ; the amethyst, is as it were tinctured with wine ; the opal varies its colour like changeable taffeta, as it is variously exposed to the light. Observe, 2. The hardness wherein some stones exceed all other bodies, the diamond in particular, which is so extremely hard, that no art is able to counterfeit it. 3. As to the uses, some are serviceable for building, and for many sorts of vessels and utensils ; for pillars and statues ; for porticos, conduits, palaces, as free-stone and marble : some to burn into lime, some (with the mixture of kelp) to make glass, as common flints : some to cover houses, as slate ; some for marking, as chalk, which serves also to manure land, and for medicinal uses ; some to make vessels which will endure the fire. I might add the warming stone, digged in Cornwall : which being once well heated at the fire, retains its heat for a considerable time.

17. Of the third class are inflammable fossils, the chief of which are SULPHUR and BITUMEN. Both are highly inflammable : but the

substance of bitumen is more fat and tenaceous; whereas sulphur may easily be broken, and reduced to a fine powder.

The bitumen of the Latins was by the Greeks called asphaltos. It is a black, solid, brittle substance, resembling pitch. It is chiefly found swimming on the dead sea, where anciently stood Sodom and Gomorrah. It is cast up from time to time from the bottom to the surface, where it gradually condenses by the heat of the sun. It burns as violently as naphtha; but is of a finer consistence.

Asphaltos is also a kind of bituminous stone, found near the ancient Babylon, and lately in the province of Neufchatal, which properly mixed, makes an excellent cement, incorruptible either by air or water. With this, it is supposed, the walls of Babylon were built.

Jet seems to be formed in the earth of a bituminous juice. It is a light smooth, pitchy stone. It is fissile, and works like amber: the best in the world is said to be found in Yorkshire. It readily catches fire, flashes and yields a bituminous smell. Nearly resembling this, is the channel coal, found in several parts of Lancashire, which burns with an even, steady flame, like a candle or torch.

18. Amber is a kind of fossil pitch, the veins of which run chiefly at the bottom of the sea. It is hardened in tract of time, and cast on shore by the motion of the sea. It was long thought that none could be found but in Prussia: but it has since been found in Sweden, on the shores of the isle Beorkoo, though situate in a lake whose water is sweet. Nay, it is digged out of the earth, at a considerable distance from the sea, and not only in sandy, but in firm ground.

19. But the most extraordinary of all fossils is the asbestos. It seems to be a species of alabaster, and may be drawn into fine silky threads, of a greyish or silver colour. It is indissoluble in water, and remains unconsumed even in the flame of a furnace.

A large burning-glass, indeed, will reduce it to glass globules; but common fire only whitens it. Its threads are from one to ten inches long, which may be wrought into a kind of cloth.* This the ancients

* Ciampini gives the following statement of the method of preparing and making the incombustible paper and cloth of asbestos.

The stone is first laid to soak in warm water; then opened and divided by the hands, that the earthy matter may be washed out. The ablution being several times repeated, the flax-like filaments are collected and dried; and they are most conveniently spun with an addition of flax. Two or three filaments of the asbestos are easily twisted along with the flaxen thread, if the operator's fingers are kept oiled. The cloth when woven is best preserved by oil from breaking or wasting. On exposure to the fire, the flax and oil burn out, and the cloth remains pure and white. Pliny says he has seen napkins of it taken after a feast, foul from the table, and thrown into the fire, and by that means were better scoured than if washed in water. A piece in china measuring 23 inches was sold for 163 dollars.

esteemed as precious as pearls. They used it chiefly in making shrouds for emperors or kings, to preserve their ashes distinct from that of the funeral pile. And the princes of Tartary at this day apply it to the same use. The wicks for their perpetual lamps were likewise made of it. A handkerchief of this was long since presented to the Royal Society. It was twice thrown into a strong fire, before several gentlemen. But in the two experiments it lost not above two drachms of its weight. And what was very remarkable, when it was red hot, it did not burn a piece of white paper, on which it was laid.

But there is a kind of asbestos wholly different from that known to the ancients. It is found, so far as we yet know, only in the county of Aberdeen in Scotland. In the neighbourhood of Achintore, on the side of a hill, in a somewhat boggy soil, about the edges of a small brook, there is a space ten or twelve yards square, in which pieces of fossile wood petrified lie very thick. Near this place, if the ground be dug into with a knife, there is found a sort of fibrous matter, lying a little below the surface of the ground, among the roots of the grass. This the knife will not cut: and on examination it proves to be a true asbestos. It lies in loose threads, very soft and flexible, and is not injured by the fire.

Yet it is sometimes collected into parcels, and seems to form a compact body. When this, however, is more nearly examined, it appears not to be a real lump, but a congeries resembling a pledget of pressed lint, and being put into water, it separates into its natural loose threads.

A stranger discovery still has been lately made. The proprietor of a forge, upon taking down his furnaces to repair them, found at the bottom, a great quantity of a substance, which upon repeated trial, effectually answered all the uses of the asbestos. It was equally well manufactured either into linen or paper, and equally well endured the fire. Upon prosecuting the inquiry, it appeared to him, that both the native asbestos (at least one species of it) and this obtained from the forge, were nothing more, than what he terms calcined iron, deprived, whether by nature or by art, of its inflammable part: and that by uniting the inflammable part, either with this, or the fossile asbestos, it may at any time be restored to its primitive state of iron.

But it is certain, there is asbestos which has no relation to iron. Both in Norway and Siberia, there are petrifying waters which pervading the pores of wood lying therein, fill it with stony particles; and when by a costic, corrosive power, derived from lime, they have destroyed the wood, a proper asbestos remains, in the form of a

vegetable, which is now no more. To which of these does the following belong?

Signor Marco Antonia Castagno, superintendent of some mines in Italy, has found in one of them a great quantity of linum asbestum. He can prepare it so as to make it like either a very white skin, or a very white paper. Both of these resist the most violent fire. The skin was covered with kindled coals for some time: being taken out, it was soon as white as before: neither had it lost any thing of its weight. The paper also was tried in the fire, and without any detriment. Neither could any change be perceived, either with regard to its whiteness, fineness, or softness.

PART THE FOURTH.

OF EARTH, WATER, FIRE, AIR, AND METEORS.

CHAPTER I.

OF EARTH AND WATER.

1. The earth, or terraqueous globe, is a congeries of many different bodies. It contains sand, clay, various sorts of earth, stones, salts of various kinds, sulphur, bitumen, metals, minerals, and other fossils almost innumerable. Upon the earth are the waters, and on or near its surface animals and vegetables of all kinds. But how was this whole mass formed into mountains, valleys, seas, rivers, and islands? Des Cartes advances one hypothesis; Dr. Burnet another; Mr. Hutchinson a third; and each world-builder advances plausible reasons for his own hypothesis. But none of those reasons are demonstrative: higher than probability they cannot go.

That the earth is round manifestly appears from the eclipses of the moon, in all which the shadow appears circular, which way soever it be projected. The natural cause of its roundness, is the great principle of attraction, which the Creator has stamped on all the matter of the universe, whereby all bodies, and all the parts of bodies, continually attract each other. By this means, as all the parts of bodies tend naturally to their centre, so they take a globulous figure, unless some other more prevalent cause interpose. Hence drops of quicksilver assume a sperical form, the parts strongly attracting each other. Drops of water have the some form, when falling in the air, but are only half round, when they lie on a hard body, because their gravity overpowers their attraction. Yet the earth is not exactly round, but swells out towards the equator, and is flatter towards the poles which is supposed to be occasioned by the diurnal rotation of the earth on its axis. By this means the greater diameter exceeds the less about thirty-four miles. What the earth loses of its sphericity by mountains and vales is nothing considerable: the highest eminence being scarce equivalent to the smallest protuberance on the surface of an orange. The diameter of the earth is supposed to be seven thousand nine hundred and sixty seven miles.

In the terraqueous globe are, 1. The external part, from which vegetables grow and animals are nourished. 2. The middle part, which is possessed by fossils, and extends farther than human labour can penetrate. 3. The internal, which some suppose to be a great loadstone; some a large mass of fire; some a collection of waters; but indeed of that we know nothing. The deepest cavities, natural or artificial, known to us, scarce penetrating a mile below the surface.

The earth is nearer the sun at Christmas than at midsummer, as appears both from the sun's apparent diameter, being greater in December than June, and from its motion, being then swifter. Hence it is that there are about eight days more in the summer half year, from March to September, than in the winter half year, from, September to March.

That the earth moves round its own axis, not the sun and stars round the earth, may appear from this single consideration. All the planets revolve in more or less time, as their orbits are greater or less. If then they moved round the earth, they must revolve in unequal times, according to their orbits; not all in the same time, in twenty-four hours, as they seem to do. Therefore they do not move round the earth; but the earth, as the rest, round its own axis.

That it moves also round the sun, appears thus: all bodies which turn round each other, must gravitate towards each other: consequently if the sun gravitates to the earth, so must the earth to the sun. Now it is demonstrable, that when two bodies gravitate to each other, without approaching each other in right lines, they both turn round their common centre of gravity. But the earth being no more than a point to the sun, the common centre of these two bodies, will be near the body of the sun itself, and in the opposite direction from the earth. The earth therefore turns round a point which is near the sun: consequently round the sun. Indeed to suppose the earth at rest, destroys all the order and harmony of the universe, annuls its laws, and sets every part at variance, with the others. It renders the motions of the planets utterly inexplicable, which are otherwise plain and simple.

Nor is the motion of the earth, whatever is vulgarly supposed, contrary to any part of the scripture. No other ideas are to be affixed to the words of scripture, than such as occur to one who looks at the thing spoken of. By the sun's rising therefore, when mentioned in scripture, we are to understand no more than the sun's appearing again in the horizon, after he had been hid below it: and by his setting, his ceasing to appear. And when the sun and moon are said to stand still, it means only, that they did not change their situation in respect of the earth: that the sun still appeared just *over Gibeon* and the moon *over the valley of Ajalon*. If it be said, "but David speaks

of the *sun running its course*," we may answer over and above, the word here used does not mean the orb or body of the sun, but always his rays or beams.

2. The earth consists of a great variety of substances, of very different characters. The principal of which are, silex, alumine, barytes, lime, magnesia, and some others of less importance. Among these silex appears to be the basis, or principal component of the whole earth; comprehending sand, pebbles, rocks, and precious stones. Sands exhibit a very great variety both in the figure of their particles and their colour.

All sands are either natural or factitious. Natural sands are those which have been in the same or nearly the same state from the creation, diffused through all parts of the earth. Sand viewed in a microscope, is no more than a parcel of little stones: doubtless therefore they must have begun to exist, and been formed by the same laws that stones were formed by. Now stones were formed first into hard and solid masses, in proportion to the quantity of similar materials, and proper cement. Where there was a great quantity of lapideous particles, and few heterogeneous mixtures, there strata, rocks, and large stones were formed. But where the lapideous particles were scattered and disunited by the intervention of other bodies, there small rubble-stones, gravel, girts, and the smallest and most numerous of all stones, sands, coalesced into minute glebes. This probably was the process in every part of the earth: so that natural sand is one of the primeval bodies, concreted at the same time with stones, upon the highest mountains, as well as in the valleys: and at the bottom of the sea, as well as upon dry land.

Besides this natural sand, there is also a factitious one, which owes its origin to the fretting of river or sea-water. For water always in motion, preys upon the stones and grinds them by degrees into stony powder which we call sand: hence it is that the sand of a particular stone, cove or bay has generally the same colour, and in a microscope, the same structure, as the rocks and stones of the adjacent cliff, and the strata under the sea, upon which the waves are perpetually working, and driving into the sea what they dash off from those strata.

3. We have heard of large bodies of sand moving together in the deserts of Arabia. But has any thing of the kind been known in England? There has, and that very lately. It is not a century, says Mr. Wright, since our sands, near Dewnham, in Suffolk, first broke prison. In a warren near Lakenheath, an impetuous south-west wind having broken the sand of some sand-hills, the sand blew upon the adjacent grounds, which being much of the same nature, the thin crust of barren earth was soon rotted and dissolved by this sand lying upon it.

and thereby fitted to bear it company in its strange progress. At its first eruption the whole magazine of sand could not cover above eight or ten acres of land. But it increased into a thousand acres before the sand had travelled four miles. Above thirty years since it reached the bounds of this town, where for ten or twelve years it did no considerable mischief; because its course was then down the hill, which sheltered it from the wind that gave it motion. But the valley once past, it went above a mile, up hill, in two months time. It overrun two hundred acres of good corn that same year. It is now got into the body of this little town, where it has buried several houses. And the remainder have been preserved at more expense than they were worth. At the other end of the town diverse houses are buried, and our pastures and meadows destroyed. A branch of the river Ouse, upon which we border, for three miles together, is more than half filled up with sand. And had not this interposed to stop its passage into Norfolk, doubtless a considerable part of that country, had ere now been left a desolate trophy of this conquering enemy.

4. One of the most considerable parts of the earth is the mountains. There is a remarkable irregularity in their figure, and, so far as we can judge, an entire neglect of order in their situation. The far greater part of them are hollow, and contain beds of stone, metals, or minerals. And doubtless such there were from the creation, although not so high, steep, or rugged.

For these vast masses are not, as some have supposed, mere incumbrances of the creation: rude and useless excrescences of the globe; but answer many excellent purposes. They are contrived and ordered by the wise Creator, for this grand use in particular, to dispense the most necessary provision of water, to all parts of the earth; without which neither animals could live, plants grow, nor perhaps fossils receive any increase. For was the surface of the earth even and level, there could be no descent for the waters, but instead of gliding along these gentle declivities, quite down to the sea, they would drown large tracts of land, and then stagnate and putrefy.

Indeed, without hills, as there could be no rivers, so neither could there be any springs, which we continually find in or near high grounds, very rarely on spacious plains. When we do find any there, it is generally at great and inconvenient depths. And even these are probably owing to hills, either near, or at some distance: as we may gather from the impetuous manner wherein these subterraneous waters break out, when wells are dug in the Lower Austria, or in several parts of Italy. And if there are some islands, which seem void of mountains, and nevertheless are well watered, in reality the whole mass of land is no other than one mountain, descending gently and imperceptibly down, from the midland parts to the sea.

5. The benefit of mountains in general is not only, that vapours driven against them are condensed, so as to be precipitated through the chinks of the rocks, but that afterwards in their bowels they are preserved till they form rivulets, and then rivers. Vapours would fall in rain or dew though there were no mountains, but then they would fall equally, over considerable places of the globe at once, and so would be sucked deep in the ground, or make an universal puddle; whereas, by means of mountains, they are perpetually pouring down in particular places, and treasuring up a constant supply to the rivers. Another considerable use of them is the determination of these rivers; for if there could have been rivers without mountains, yet they could only have run in a straight line, if they had run at all; whereas by these eminences, placed up and down, they make innumerable turnings and windings, whereby they enrich, fatten, and water the soil of several different countries in one course, and at last disembogue in several mouths into the sea. Lastly, most hills are the nests of metals or minerals. These by the efficacy of subterranean heat, converting the adjacent earths into their substance, grow as truly as animals or vegetables. I just mention their use for the production, shelter, and nourishment of some sorts of vegetables and animals, which could not grow or live so well any where else. But from the whole, we may see of what advantage these unsightly moles (as some thought them) are to the accommodations, and even necessities of life.

6. The height of Snowden-Hill, generally supposed to be the highest in Great Britain, is 1240 yards. But Skiddow-Hill, in Cumberland, is 1760 yards high from the level of the lake beneath. And Conagra which rises gradually from the head of the bay at St. Kilda, one of the western islands of Scotland, is 1800 yards high; so that this may justly be stiled the Teneriffe of Great Britain. The height of several mountains in France is as follows:

		Feet.
Bugarach in Languedoc		3888
Le Puy de domme	In Auvergne	4860
Le Courland		5088
Le Coote		5106
Le Cantal		5904
Le Mont d'or		6180
Le Mont Ventoux in Avignon		6216
The height of the Pyrenean mountain is,		
St. Barthelemi		7110
Le Montagne des Mausset		7548
Le Conigoe		8640

Probably these mountains may vie in height with most in the known world. Yet above all these is the Stella Piz Hail, a steep mountain

in the Grisons, which is 9585 Paris feet above the level of the sea; a height which the wild goats themselves scarce venture to ascend.

But Mr. Martel informs us, that the highest point of Mont Blanc is higher even than this: that it is 2076 toises above the level of the Rhone, which added to the height of this above the sea, makes 13,115 Paris feet, or above two English miles, and two-thirds of a mile. If so, this is the highest mountain in Europe, and perhaps in all the world: unless you except Mount Athos in Macedonia: which according to the account of Riccioli, who measured it exactly, is 10.000 Italian paces high, carrying its top above the winds and clouds: a clear proof of which, is, that whatever is written there in ashes or light sand, is found there, just as plain as at first, after several months or years.*

"But is not the celebrated Mount Atlas in Africa, the wonder of all ages, far higher than this?" One who saw it, and travelled all over it, is best able to answer this question. He writes thus:

"Barbary is bounded on the south by Biledulgerid, from which it is divided by Atlas, a chain of mountains, but not of that extraordinary height or bigness, which the ancients, attributed to it. Those parts of them, says Dr. Shaw, which I have seen, are rarely, if ever, equal

* The summits of some mountains are so elevated, that a breeze of wind never plays upon them, even the vapours seldom reach to their tops, and they rest in perpetual tranquility. When the human vapours sometimes attain to that degree of elevation, they are condensed in snow and ice, adhere to their tops, and remain undisturbed for ages. But these are always mountains of that particular description, whose summits are terminated in sharp ridges, or points; and whose sides are very steep: mountains of a wedgelike shape, whose apex reaches above the region of conflicting elements. Hence we learn that the turbulent regions where storms and meteors rage, where thunders roll, and lightnings play, are confined to narrow limits, near the more uniformly expanded surface of the earth. Hence we may also infer, that all the phenomena we observe in our earth and atmosphere, are a natural consequence to the interposition of the solid and inflexible earth, between the centre and circumference of the globe. For there is reason to conclude that if the earth was flexible like the air, to its centre, it would yield to the various compressions of the atmosphere, and the powers of repulsion would be lost. The atmosphere as it is compressed to the earth bounds from it, and finds its passage along the surface, and these currents we call winds. It is a philosophical and rational inference that if the atmosphere were uniformly dilated to an equilibrium, proportionate to its density, every thing would become poized in invariable stillness in its regions. Any rarefied bodies escaping from degrees of density exceeding their own, would gently rise till they attained that degree which corresponded to their specific kind, and there remain stationary. But the all-wise Creator has provided against this catastrophe of worlds, and stampt the indelible powers of attraction on matter. So that particle is related to particle, bodies to bodies, and worlds to worlds. And these relations are undoubtedly coextensive with the universe: were it otherwise all nature would sink into chaos: the plain would be as the mountain, and the centre as the circumference.

to some of the mountains on our own island, and cannot any where stand in competition with either the Alps or Appenines. Atlas is a number of hills, usually 4, 5, or 600 yards high, with an easy ascent, and groves of fruit and forest trees, rising up one behind another.—Only here and there is seen a rocky precipice, of a superior eminence."

The rivers of Indus and Ganges, before they enter the ocean, contain between them a large Peninsula, divided in the middle by a ridge of high hills, which runs from east to west, quite to Cape Comorin. On the one side is Malabar, on the other Coromandel. On the Malabar side it is summer from September till April; a clear sky, and scarce any rain. This is winter on the Coromandel side, every day and night yielding abundance of rain. So that as you cross the hills to St. Thomas, in little more than twenty leagues, you ascend the hill with fair summer weather, and descend with a stormy winter.—There is a like ridge of hills in Jamaica running from east to west through the midst of the island. On the south side of these, there is summer from November to April; on the north side winter; and so vice versa.

Hence it appears, that not the lessening the gravity of the atmosphere only, is needful to produce rain, but likewise a change of winds or a ridge of hills, to drive the particles of the vapours together.—And hence it is that while the wind blows from north-east in Coromandel, and on the north side of the mountains in Jamaica, there are continual rains, and constant fair weather on the north side of the mountains, and in Malabar. Whereas while it blows from the south-west, there are constant rains on the south side of the Jamaica mountains and in Malabar; but constant fair weather on the north side of those mountains, and in Coromandel.

This also may account for the singularity of seasons in Peru, which runs southward from the line above a thousand leagues. It is divided into three parts, long and narrow: the Lanos or plains, which run along the sea-coasts, the Sierras, which are hills with valleys intermixed, and the Andes, which are steep and craggy mountains. The Lanos are, some ten leagues in breadth, some less and some more. The Sierra is twenty leagues in breadth, and the Andes the same. It is remarkable, 1. That in the Lanos, the south and the south-west winds continually blow. 2. That they never have any thunder, hail, snow or rain, only sometimes a small dew. 3. On the Andes it rains almost continually. 4. In the Sierra, which lies between, it rains from September to April, and is clear from April to September. The reason is plain; the constant wind blowing over the Lanos, finds nothing to stop it, and drives its vapours into rain. But the Andes continually intercept these vapours, and so occasion continual rain. The Sierras

being lower, intercept the vapours only from September to April, because then the sun being nearer the atmosphere is lighter, and consequently the vapours sink lower.

In regard to this, there are two or three acts of Divine Providence which are highly observable. One is, that all countries throughout the world should enjoy the benefit of mountains placed here and there, at due and proper distances. According to the natural course of things, when the earth and waters were separated, and ordered to their respective places, the earth would have been one even surface. The several component parts thereof must have subsided according to their specific gravities, and at last have formed a large, even, spherical surface, every where equidistant from the centre of the globe. But that instead of this form, it should jet out every where into hills and dales, is a manifest sign of the special providence of a wise Creator. Another sign of this is, that throughout the whole earth, the parts farthest from the sea are the highest: an admirable contrivance both for supplying all places with water, and for carrying off the superfluity of it.

And as the mountains themselves are naturally disposed to be drier than the low grounds, so nature has provided for them, a more plentiful supply of moisture, unless for that very small part of them which ascends above the clouds and vapours. For besides the fountains which water them continually, they have more rains and dews than the valleys. They are much more frequently covered by fogs; and by stopping and compressing the clouds, as well as condensing them by their greater cold, they procure all the rain they want.

"But how were the mountains formed after the flood had dissolved the terraqueous globe?" Probably thus. The smaller hills might easily be aggregated by the mere force of the water. But the mountains being of a denser substance, seem to have been elevated from beneath, in a convex form, by the violent force of subterraneous wind, water and fire, heaving them up, and scattering them abroad in so many protuberances. And if this was done before the substance of the stones became fixed and indurated, then it is no wonder that the external wind likewise should leave so manifest tokens of its vehement impetuosity, in the extent and outward figure of them. This gives an easy, natural account, for the innumerable fissures, chasms, and disruptions, whereby so many mountains are, as it were, sawn asunder, either across or lengthways. And hence many such apertures in the mountains, are filled with slimy matter which was afterwards indurated. In some of the mountains of Norway, this projects in a range, about an ell in breadth, betwixt the other stony strata, through the whole length or bulk of the mountain, and from the variety of its colours, makes a very pleasing appearance. Of these

veins, some consist of marble or alabaster, some of agate, white, red, or blue stone, which, especially towards the sea, where the rocks are bare, form many curious variegations. Hence likewise there remain on the surface many detached blocks and fragments, scattered not only in the valleys and creeks, but on the tops of the highest mountains.—Many of these are of the bulk of a common house, and consequently too ponderous, to have been raised to such an immense height, by the hands or art of men.

But the largest mountains it has been conjectured, have been formed in the following manner. The sea-waters doubtless remained some time on the earth: and during that time the surface of the earth was the bottom of the sea, where every thing passed in the same manner as passes at the present bottom of the sea. Now the sea has always had a flux and reflux, and that most violent under the equator, where likewise the earth's motion causes a greater centrifugal force than any where else. Suppose then the earth was at first quite round, yet its diurnal motion, with the flux and reflux of the sea, would have raised by degrees the parts near the equator by amassing there shells, mud and earth. And as this is performed daily, the water would carry at each time a small quantity of matter, which afterwards sinks to the bottom, and forms those parallel strata, which are every where found.

Thus in fact, on many shores the flux brings a great number of things along with it, and leaves them there. So that while it insensibly covers some lands, it abandons others, after adding thereto shells, earth and sand which, gradually accumulating, make a part of the continent.

On a coast against which the sea beats violently, it carries a little soil away at each tide. Yea, even where it is bordered with rocks, it wears them away by little and little. These particles the waters carry to a certain distance, where they sink in the form of a sediment, and form the first stratum, which will soon be covered by another, and so with more and more. Hence in time a mountain will be formed in the bottom of the sea, entirely like what we see on the land.

Such eminences lying in the same direction with the waves that produced them, form by degrees a chain of mountains. "But how come mountains, whose top is composed of rock, to have only earth or sand for their base, which may often be seen in the neighbouring plains, to a considerable distance?" We answer, the water first transported the sand that formed the first layer at the bottom of the sea. Afterward the more firm and weighty substances were attacked, and brought by the waters in an impalpable powder. And this powder of stone formed the rocks which cover these eminences.

These causes act with more force under the equator, as the winds are there more uniform, and the tides more violent: and accordingly the greatest chain of mountains is near the equator. Those of Africa and Peru are the highest we know, which after traversing whole continents, stretch to very considerable distances, under the waters of the ocean. The mountains of the north are not equal to these. Moreover the number of isles in the northern seas is inconsiderable, while there is a vast quantity under the torrid zone: and an island is no more than the top of a mountain.

It is then doubtless the general flux and reflux of the sea, which has produced the greatest mountains. But others we may ascribe to currents, winds, and other irregular agitation of the sea, which must, by their various combinations, infinitely vary the direction of the tides. They are the smallest of all which owe their rise to earthquakes, or to accidental causes.*

But how shall we account for the formation of the Iron Mountain, near Taberg, in Sweden? It is situated in a mountainous part of the country, covered with sand, near forty leagues from the sea. It is an entire mass of rich iron ore, the perpendicular height whereof is above four hundred feet, and its circumference three English miles. Opposite to it is a valley, through which flows a small river. No ore is found beyond the foot of it, nor on the neighbouring plain, so that it appears as if the mountain had been artificially laid on the sand. For it has no roots like other mountains, nor does its substance penetrate the ground. It has all over, many perpendicular and horizontal fissures, filled with pure sand: in the inner parts whereof bones of stags and other animals are found.

No hypothesis hitherto advanced to account for the formation of mountains, will at all account for this. The bones found therein shew it was owing to some ruinous cause. But what that cause was, must in all probability ever remain a secret.

* Mountains may be regarded as a species of excrescence, formed by subterraneous currents of certain gasses. And though their causes do not become visible, and they do not break out in torrents of liquid fire: though no opening is observed, or lava seen; yet they frequently exhibit appearances highly volcanic. In some, smoke has been seen to issue from their summits or sides, as if the lava were already formed, and ready to burst forth from its imprisonment. Others have assumed the shape of volcanic mountains, aspiring in regular cones, and have exhibited all the volcanic appearances excepting actual eruption. While others have extended in a linear direction, similar to the effects of earthquake, traversing in veins and ridges to a vast extent. Indeed if any circumstance were to occur, to diminish the ordinary compression of the atmosphere on any portion of the earth's surface, it would almost seem as if that portion of earth would arise protuberant and in process of time become a mountain, which would continue to grow until it attained to that degree of elevation where the density of the medium corresponded to the repelling power which heaved it from its base.

No less unaccountable are some of the mountains in Iceland, termed by the natives, Jokeler. From the tops of these continually flow large streams of a thick, sooty, stinking water. These occasion lakes which increase in bulk, and again diminish, and change their appearance almost every day. Hence paths are seen in the sand made by travellers that passed the day before. When followed, they lead to a large pond or lake, which obliges them to go two or three miles round, and then they come to the very path opposite to that which they were obliged to leave. But in a few days the lake is, as it were vanished, and the uninterrupted path appears again.

7. A body that yields easily to the touch, and whose parts making but little resistance against being divided, move among themselves with great facility, is usually termed a fluid. Liquids are a sort of fluid which assume the figure of the vessel they are contained in, and always keep their upper surface in a plain, parallel to the horizon. Such as water, oil, mercury, which are distinguished from their fluids, by the parallelism of their surface, in consequence of their weight, and the intestine motion of their parts all manner of ways. That they have such a motion, plainly appears, from their dissolving hard bodies. Put a piece of copper into a glass of aquafortis, and there is first an effervescence, then the copper diminishes, and at last disappears And what strong waters are with regard to metals, other liquids are to other substances. Each of them is a dissolvent, more or less, according to its component particles. Now it is plain that dissolution supposes motion, and is the effect of it. There is therefore in all liquors an intestine motion, from which this effect results.

Water is a transparent liquid, capable of heat and cold, and of being rarefied into vapour. But it is not capable of being condensed, by any method yet known. It is of itself without smell or taste, and liable to putrefaction. It is heavier by many degrees than air, and insinuates where air cannot enter. These properties do unquestionably depend on the figure and texture of its parts. But these, after our most curious researches, it is not possible to know with certainty. Dr. Boerhaave says, no one ever yet saw a drop of pure water. It is never pure from salts. For all water contains air, and all air contains salts.

The particles of water are generally allowed to be round. This figure indeed is probably inferred from its fluidity. Allowing then the particles of it to be round, fluidity must be an essential property of all quantities and assemblages of it. For take any mass of round bodies, (bullets for instance, pebbles or the like) they will not cohere or rest by one another without force, but will flow on every side, till they meet with such resistance from external bodies, or rather internal gravitation, as shall prevent further motion.

The particles of water are unalterable, for passing into so many bodies, and through such alternate extremes of heat and cold, if they had not preserved their essential properties constantly, moisture since the beginning of the world, must have very sensibly diminished.* But seeing no such deficiency appears, and that springs, rains, and rivers, are as abundant now as they anciently were, (as by the rising of the Nile for many ages, among other reasons may appear) we are to conclude, though waters may be transplanted, they can neither be transmuted nor destroyed; and wherever removed they will make their appearance again when at liberty, in the same liquid state as they were before.

The particles of water are exceeding small: for they may be so divided from each other, that one square inch of common water shall, when rarefied, fill a space of 14,000 square inches. And it is computed that at least 13,000 particles of water may be held on the point of a needle. By this it appears, that what we call water is an assemblage of small transparent globules, which are composed again of an infinite number of smaller particles or atoms of this elementary liquor.

Water seems to be diffused every where, and mixed with all bodies. Fire itself is not without it. Place salt of Tartar near the hottest fire, and it will imbibe water, and thereby in a short time, considerably increase in weight. So a pewter vessel with ice in it, brought up from a cold vault into the hottest room, in a dry summer day, is immediately covered with little drops of water, which is gathered from the air, and condensed by the coldness of the ice.

Indeed the quantity of water which is afforded by the driest bodies is surprising. Oil of vitriol long exposed to a violent fire, to separate it from all its water, by only standing a few minutes in the air will afford as much as at first. Hartshorn kept forty years, and turned as hard and as dry as any metal, so as to strike fire with a flint, yet distilled in a glass vessel, will yield an eighth part of its quantity in water. Bones dried five and twenty years, and almost as hard as iron, have by distillation yielded half their weight in water. Yea, the hardest stones, ground and distilled, always afford a portion there-

* Water was formerly considered as a simple elementary body, but this is now ascertained to be an error; it is found to be a compound, of different gassious substances, which in a state of union, form water; but in the abstract state form solid bodies, or an integrant part of the atmosphere. The doctrine of the unalterable and essential properties of water as it applies to the invariable capacity of its constituent parts, is undoubtedly correct; and that the quantity of its constituent parts is in equilibrium with the other parts of our globe. But it is not now deemed correct, as it respects the component parts in union, or in the state of water.

of. All animals and vegetables grow out of water and salts, and by putrefaction return to the same.

The chief properties of water are, 1. It is next to fire, the most penetrative of all bodies. So that a vessel through which water cannot pass, will contain any thing. Only some oils will pass through those wooden vessels, which contain water. Not that their particles are more penetrative: but those woods abound with rosin. This the oil dissolves, and then makes its way through the spaces left thereby. Water also by degrees makes its way through all wood, and is only retainable by glass and metals. It finds its way where air cannot, as through leather, which air cannot penetrate. Again, air may be retained in a bladder: but water oozes through. Yea, experiments shew, it will pass through pores ten times smaller than air will. By this very quality it is fitted to enter into the composition of all bodies, animal, vegetable and fossil; with this peculiar circumstance, that by a gentle heat it is separable from them again. By this, joined with its smoothness, it is fit to convey the nutritive matter of all bodies. Passing so readily, it never stops up the pores, but leaves room for the following supplies. And yet, 2. Water, which so easily separates from most bodies, firmly coheres with some: yea, binds them together in the most solid masses. So mixed with ashes, it gives the utmost firmness. The ashes, for instance, of an animal, wrought up with pure water into a paste, and baked with a strong fire, grows into a copel, which bears the utmost heat of a refiner's furnace. It is in truth, by the glutinous nature of water alone, that our houses stand. For take this out of wood, and it becomes ashes; out of tiles, and they become dust.

Indeed all the stability and firmness in the universe, are owing in part to water. Thus stone would be incoherent sand, did not water bind it together. And thus of water and clay we make earthen vessels, of the utmost hardness and closeness. And these, though appearing perfectly dry, yield, when distilled, an incredible quantity of water. The same holds of metals, parings, or filings, which by distillation, yield water plentifully. Yea, the hardest stones, sea-salt, nitre, vitriol, are hereby shewn to consist chiefly of water.

Hence we learn that the component particles of water are, 1. Infinitely small, whence their penetrative power. 2. Exceeding smooth and slippery; hence their fluidity, and easy separation from other bodies. 3. Extremely solid. 4. Perfectly transparent. 5. Hard, rigid, and inflexible: as appears from the absolute impossibility of compressing them.

Salts melted in water, do not fill the vessel in proportion to their bulk. It follows, that there are spaces between the particles of water, to admit those of the salt. Hence also we gather, that the

watery particles are extremely solid and inflexible, since notwithstanding those spaces, no power can compress, or force them nearer each other.

8. When the particles of nitre that float in the air, wedge the particles of water together, they become ice. The air lodged in the pores of the water, is then greatly expanded. Hence the water is lighter than before: but at the same time it is less transparent: perhaps because the passage of light is hindered by the interposal of these nitrous particles.

It is observable, 1. That all liquids, except oil, dilate in freezing and grow lighter. Nay, even after they are thawed, they are considerably lighter than before: 2. That water will not freeze *in vacuo*: 3. That water which has been boiled does not readily freeze: 4. That water covered with oil of olives does not freeze readily; covered with nut oil, not at all: 5. That nut oil, oil of turpentine and spirits of wine will not freeze at all: 6. That frozen water is covered with wrinkles, something like rays drawn from the centre to the circumference.

Though fluids are dilated near a tenth of their length, metals are shortened by frost. If vessels made of metals, however thick and strong, be filled with water, close stopped, and exposed to frost, the water will burst the vessels. A strong barrel of a gun, thus filled and stopped, will rend the whole length.

Dr. Plott observes, that rivers are always found to freeze first at their bottom. The same is observed by watermen in the Thames, who not only feel it at the bottom with their poles some days before the surface is froze over, but see it rise up from the bottom, so as to dart up in pieces edgeways, half a foot, sometimes a foot, above the surface. In this posture it continues a little time, and then turning flat upon the water swims along the stream, till it meets with other pieces, which if the frost continues, all harden into one, till the river is froze over.

"In a part of the Thames, where there was very little stream, I found the water, (says Dr. Hale) in a cold morning froze one fifth of an inch thick, under which I saw a bed of ice at the bottom. Breaking away some of the upper ice, I took up some of the lower ice, which was about half an inch thick. It adhered close to the bottom, where the stones and sand were incorporated with it. When it freezes to a considerable thickness, it will raise up with it from the bottom the fishermen's osier wheels, although they are sunk down with stones or bricks tied to them.

"Standing waters indeed freeze first at top, because they are coldest there: whereas in a stream the upper and lower waters being continually blended together, are equally cold: and the upper water

mean time having more motion, cannot freeze so soon. But here, where the motion of the water was so small, its surface was froze as well as the bottom, though not so thick: whereas the main river, where its motion was greater, was not froze over, though cakes of ice were continually rising from the bottom."

It has been commonly supposed, that fluids not only dilate, but evaporate by cold. And this has long passed for an incontestable truth. Yet it is altogether a mistake. From later experiments it undeniably appears, 1. That cold does not increase, but lessen the evaporation of water, if it be not exposed to the agitation of the air: 2. That the evaporation of water depends on an intestine motion, which it preserves as long as it is liquid, and that the air only contributes thereto, by continually transporting the particles detached from the surface, and thereby giving other particles room to disengage themselves: 3. That frozen water does not evaporate at all, if it be kept from the agitation of the air: 4. That the diminution observed in ice exposed to the open air, is not from any evaporation, but is the effect of a fine rasping by the wind, rubbing against it and carrying off its finer particles. And what is thus detached from ice is only a very fine dust, not more different from ice than the dust of free-stone, cut from the stone itself.

This dust carried by the wind produces intense cold. Nor is it always invisible. The air near Hudson's Bay is often filled with particles of ice, fine as hairs, and sharp as needles: which if they strike against the hands or face, pierce the skin and occasion painful blisters.

The natural state of this globe seems to be in an intermediate degree between heat and cold. And this natural warmth of the earth is what secures many springs from being frozen: the frost in England seldom penetrating the earth, more than fourteen inches below the the surface. Even in Sweden bubbling springs do not freeze at all, while the standing waters freeze three ells deep.

In the lakes of Sweden the ice often cracks, with a rupture nine or ten feet deep, and many leagues long, and with a noise like cannon. Hereby the fishes get air, so that few of them are destroyed. In Moscow the earth is often cleft by the frost, a foot broad, and many yards long. In the mountains of Switzerland, there are vast masses of ice, which have lain there for many centuries. At certain times these crack, and by those cracks one may guess at the immense thickness of them: some of the cracks being three or four hundred ells deep, though none of them have ever gone through the whole thickness of the ice.

We need not then be surprised, at the effects of severe frost on trees and other vegetables. How these are hurt in hard winters is easily understood, if we consider, that water when frozen, takes up

more space than it did before: that all trees, especially those that shed their leaves, drink in a large quantity of moisture in summer, and that the vessels of small twigs are larger in proportion than those of the trunk, and consequently contain more moisture. It follows, that being surprised by a hard winter, before their juices are diminished, or changed into a glutinous nature, which does not so easily freeze; the vessels of the tree must necessarily burst. Consequently their juice must be extravasated, and so cause, as in animals, the death of the tree, by a kind of bleeding, which nothing can stop.

In the great frost in 1683, oaks, ashes, and walnut-trees, were cleft in two, and frequently with a terrible noise, and not only their bodies, but their branches and roots also. In 1708, the frost was almost through all Europe, except Scotland and Ireland. All the orange-trees and olives in Italy, Provence, and many other countries, perished, and all the walnut trees in France, with an infinity of other trees. In England most of the bay-trees, hollies, rosemary, and even furze, perished. The sap also of wall-trees, stagnated in the branches, and produced disorders resembling chilblains. And the very buds of the finer trees were quite killed, and turned into a kind of mealy substance.

In 1728, toward the end of November, the wind blew exceeding cold, followed by so heavy a snow, as in one night broke off large arms of many evergreen trees. At this time also, there was a great number of large trees disbarked. Two West-India plane-trees, in particular, in the physic-garden at Chelsea, which were near forty feet high, and a fathom in circumference, were disbarked almost from the bottom to the top, on the west side of the trees. And it was observable, that whatever trees were disbarked, it was on the west or south-west side.

On the 14th of December, 1759, there was at Petersburg, the most excessive cold weather that ever was known, even to 205 degrees of De Lisle's thermometer. At that time professor Braun repeated Fahrenheit's experiments, in order to produce excessive cold by means of spirit of nitre combined with snow. He saw with surprise, the quicksilver in the other thermometer descend even to 470 degrees: there the quicksilver remained fixed in the open air, for the space of a quarter of an hour, and did not begin to rise, till it was carried into a warm room. He repeated the same experiment, first with the same, and then with another thermometer, with the same success. But as Mr. Braun had not broken the glasses, he could only at that time form a conjecture. On the 17th he produced again cold equal to that of the 14th, and communicated his discovery at a meeting of the academy. On the 25th of December, in the morning, between nine and ten, De Lisle's thermometer was at the 199th

degree of cold, and Mr. Braun, as well as professor Æpinus, repeated this experiment. As soon as the former observed the quicksilver immoveable in the thermometer he broke the glass and found the quicksilver frozen, but not entirely: Mr. Æpinus' thermometer fell with extreme rapidity, almost to the 500th degree, and in breaking the glass from below, he found the quicksilver contained in it absolutely frozen. Both the gentlemen found, that the quicksilver thus rendered solid, bore hammering and extension, like other metals; but being exposed to the open air, it recovered its former fluidity in a little time.

Mr. Æpinus went farther, to examine the quicksilver, when it was made solid. He poured quicksilver into a glass tube, as thick as one's finger, closed at the bottom, but open at top.

The quicksilver in this cylinder, which was about one inch and an half long, froze in three quarters of a minute; and became solid, perfectly resembling other metals. Mean time it continually contracted, its surface, which was at first pretty high, sunk very low, and the cylinder of frozen quicksilver sunk to the bottom of the fluid quicksilver. We know the contrary happens to water frozen and other fluids, which extend as they become solid, and their ice swims in the fluid matter, of which they were produced.

The bodies of ice in the northern seas, near Hudson's Bay are surprising; some of them are immersed a hundred fathoms or more, under the surface of the ocean. They stand a fifth or sixth part above, and are three or four miles in circumference. These floating mountains owe their durable nature, to a cause not usually observed; that is, to their not being common ice, but the ice of sea water. If a phial of sea water be exposed to the air in frosty weather, till flakes of ice are formed therein, and then set in a warm room, still the flakes will remain a long time undissolved, and if they are taken out, and exposed at a small distance to the fire, they will not run into water as common ice does; but will by degrees evaporate, leaving only a little white salt. It is easy then to conceive, that the immense masses of this ice found in the northern seas, will continue undissolved throughout the year, and at the return of the freezing season, grow larger and larger every year, by the freezing of more ice about them.

On the contrary, there are some waters, which will not freeze at all. The lake Ness, in Scotland, never freezes, be the winter ever so severe. Yea, while every thing round is frozen, its waters run smoking for six miles down the river into which they are discharged; and from this smoke there rises a sort of fog, which overspreads the country, for several miles. Near the lake is a mountain, on the summit of which there is another lake, which is always full, summer and winter. Due west from the river, there is another lake, two miles

long and six broad. The middle of this is sometimes dry, and then plainly appears to have been once an inhabited country. There are many tumuli to be seen under water, one of which is accessible at low water. And in this urns have been found, which leave no room to doubt of their having been burial places.

There are likewise in Scotland other lakes, which freeze only at peculiar seasons. A little lake in Statherick, never freezes over, be the frost ever so sharp, till February. But after the first part of this month, a slight frost will freeze it over in a night's time. There are also two other remarkable lakes in the same country. The one Lough Monan, which is considerably large, observes the same rule, freezing over in February with a slight frost, but never before, be the season ever so rigorous. The other in Straglash has a contrary quality. It lies between two high hills, and is itself considerably above the level of the rest of the country. This freezes continually, having ice in the middle, even in the hottest summer months, while the sun, by reflection from the hills on each side, gives a very considerable heat. There are many other lakes in the neighbouring country which yet have no such property: so that this, and the property of the two other lakes, must be owing to some peculiar cause. The herbage about the sides of the last lake mentioned, has a kind of perpetual spring, which continues throughout the whole year, and is much esteemed by the country people, for feeding cattle in one month, more than the best land in the country will do in two. The lake is very deep, and the water does not manifest any particular quality.

9. Rain and snow which rise in vapours, both from the earth and waters, descending on hills, sink through the earth, till they meet with a bed of clay or stone. This retains the water and gathers it together, in a larger or smaller basin, till running over the edge, it makes itself away, and rises in a fountain. Hence issues a rivulet, many of which joining together, constitute a river, which continues its course, till it empties itself into the grand receptacle of water, the sea.

But it has been asked, "is there a sufficient quantity of vapours raised in the ordinary course of nature, to supply the demand of fountains and rivers?" We answer, there is abundantly sufficient, from the surface of the sea alone, leaving the earth out of the account. For it has been shewn by clear experiments, 1. That water salted to about the same degree as sea water, and exposed to heat equal to that of a summer's day, did from a circular surface, eight inches in diameter, evaporate 6 ounces in 24 hours. If so, the thickness of a skin of water, evaporated in 2 hours, is the 53d part of an inch. But were it only a 60th, it would exhale the 10th of an inch in 2 hours. And on this principle every ten square inches of the surface of water,

yield in vapour a square inch of water daily: each square foot, half a pint: every space of four feet square, a gallon: a mile square 6914 tons: a quantity abundantly sufficient to furnish both dews, rains, springs, and rivers. So that we need not have recourse for supplies to the great abyss, whose surface at high water, is surmounted several hundred feet even by ordinary hills: and some thousands by those vast mountains, from whence the largest rivers take their course.

Nevertheless we may allow a different rise to those springs, which ebb and flow with the sea: as likewise to those lakes whose water is salt, and which have sea-fish in them, although they have no communication with any sea, by any visible passage.

To explain this a little more at large. It is evident from experience, that a vapour is perpetually rising from the sea, rivers and lakes. The winds carry this vapour through the atmosphere, in the form of a cloud or mist. When it meets with a colder air, or is stopt by mountains, it condenses, and falls to the earth. As it falls, it finds several chinks and crannies, through which it insinuates into the mountains, and lodges there, till increasing its store, it bursts out and takes the name of a fountain.

That this is really the case, will easily be allowed, by all who seriously consider, 1. That the vapours rising from the sea, are more than sufficient to supply both the surface of the earth, and the rivers with water. 2. That the mountains by their particular structure arrest the vapours that float in the atmosphere, and having collected them in their reservoirs, dismiss them again through their sides, either in perpetual or intermitting currents.

With regard to the first, it has been shewn, that every ten square inches of the surface of the sea, yields a square inch of water daily; every square mile 6914 tons: and pursuing the some proportion, every square degree, or 69 English miles, will yield 33,000,000 of tons. Now if we suppose the Mediterranean to be 40 degrees long, and 4 broad, at a medium, which is the least we can suppose, its surface will be 160 square degrees: from whence there will in summer evaporate daily 5280,000,000 of tons.

The Mediterranean receives water, (to say nothing of small and inconsiderable streams) from eight large rivers: the Iberus, the Rhine, the Po, the Danube, the Neister, the Borysthenes, the Tanais and the Nile. Now suppose each of these convey ten times as much water to the sea as the Thames. The Thames has been shewn to pour daily into the sea 203,000,000 of tons. Therefore all those rivers will produce 1827,000,000 of tons. But this is little more than one third of the quantity daily evaporated from the sea. How prodigious a quantity then remains for rains and all other purposes!

Let us observe, secondly, how the mountains arrest, and collect these vapours, and then discharge them in springs.

The tops of mountains in general abound with inequalities, cavities, grottos and gaping cells. The floating vapours are stopt by these and by their pointed summits, and being condensed thereby, precipitate in water, easily penetrate through sand and lighter earth, and gather in basins of clay or stone, till they overflow and work a passage through the side of the mountain.

And yet we need not deny, that some springs may arise from the sea, or the great abyss: those in particular, which at all times afford the same quantity of water. Some of these are found in almost every country. There is one near Upminster, in Essex, which in the greatest droughts, and when all the brooks are dried up, is little, if at all diminished. And in the wettest seasons it is not increased, unless violent rain falling into it, or running into it from the higher grounds, raise it for a day or a few hours.

As to the manner how the water rises in such springs it may easily be represented, by putting a small heap of sand in a basin, and then pouring in water. Here the sand will represent the dry land, and the water the sea round about it. And as the water in the basin rises, to or near the top of the heap, just so do the waters of the sea rise to the top of the land with which it communicates.

10. Some think the earth entirely covered the sea, till at the deluge *the fountains of the great deep were broken up*. And it is highly probable, there is still an abyss of waters within the earth, which has an uninterrupted communication with some part of the outward sea.

Some have been of opinion that the immediate cause of the deluge, was a comet, which, as Mr. Whiston shews, passed toward the sun, just before the earth, at that time. The consequence of this must be, that when it came near the earth, it would raise a vast and strong tide, both in the waters that were on the antediluvian earth, and also in the great abyss, which was under the crust of the earth.* This tide

* Much speculation has been indulged concerning the deluge. Some have conjectured that it was occasioned by the approach of a comet towards the sun which passed near the earth, and occasioned extraordinary tides by which the earth was overflowed. Others have ascribed it to an extraordinary compression and consequent condensation of the atmosphere, by which it was converted into water and which fell in such torrents as to overwhelm the whole earth. But to whatever cause it may be considered as ascribable, there is no question but the power that created the world, was competent to effect the purpose by whatever means he saw fit. However there is one circumstance which has generally been overlooked in the reflection, that it was the effect of tide; that is, the flux and reflux. If the flux was extraordinary the reflux would be equally so. For the reflux is a depression of the waters from their mean elevation always in propor-

must increase all the time that the comet was approaching toward the earth; and would be at its greatest height, when the comet was at the least distance from it. That by the force of this internal tide, as well as by the attraction of the comet, the abyss, which was nearly round before, would then become oblong. And that this must immediately extend, and then burst the incumbent crust. And thus, according to the expression of Moses, *the fountains of the great deep were broken up.*

Again. That as the same comet for a considerable time involved the earth in its atmosphere, it must have lost a vast quantity of its vapours, most of which would fall on the earth in violent rain. And that thus *the windows of heaven were opened.* To remove this vast orb of water, they suppose a mighty wind to have risen, which dried up some, and forced the rest into the abyss again, through the clefts by which it came up. Only part of it stayed in the channel of the ocean, now first made to receive it, and in the lesser cavities, placed up and down on the surface of the globe: But this is mere conjecture.

The present distribution of the waters and dry land, though it may seem rude and undesigned to a careless view, yet is admirably well adjusted to the use and conveniences of our world. In the first place, they are so distributed all the world over, that there is a just equipoise of the whole globe. The Northern balances the Southern ocean; the Atlantic, the Pacific sea. The American dry land is a counterpoise to the European, Asiatic, and African.* In the next place, the waters are so admirably well placed about the globe, as to

tion to their rise above it. And if the tide afflux, was so great as to cover the whole surface of the land, even the highest mountains, the reflux would also be so great that the ocean in many parts would desert its bed, and the bottoms of whole seas would be laid bare. Whereas on the other hand the waters of the general deluge are represented as uniform and unabating for many months, which renders abortive the idea, that it was the effect of tide. Objections equally serious would apply to the other proposition that it was an effect of the interference of any other orbit with our own, for still the action would be on a point of the circumambient space, which would render the effect diurnal: and which would at once annul every argument in favour of the hypothesis. It would seem as if there was no plausible way of accounting for the phenomenon in the course of natural events, but by saying, that such a quantity of aqueous gasses was emitted from the earth as yielded to the pressure of the superincumbent atmosphere by which the contiguous strata of our atmosphere was converted into water, and so the effect produced. But even here the quantity of aqueous matter would appear to exceed the equilibrium on which the earth is poised. Hence it would seem vain to search for the cause as a natural event, and it must be considered as the effect of supernatural power.

* The uniform gravitation of the globe to its centre, entirely does away the idea of a balance of its parts. It would make no difference if all the land was in a heap together, as both land and water are alike amenable to the common law of density.

afford sufficient vapours for clouds and rain, to temper the cold of the northern and southern air, to mitigate the heats of the torrid zone, and to supply fresh waters to fountains and rivers. Nay, so abundant is this great blessing, that we have more than a bare sufficiency, even a surplusage of this useful creature: and yet so well ordered, as not to drown the earth, not to stagnate, putrefy or annoy its inhabitants: but to glide gently through convenient channels back again to its grand fountain, the sea: and many of the rivers through such large tracts of land, and to such prodigious distances, that it is a wonder the fountain should be high enough, or the sea low enough for so long a conveyance. Witness the Danube and Wolga in Europe, the Nile and Niger in Africa, the Ganges and Euphrates in Asia, with the Amazon's river and Rio de la Plata in America. No accidental currents or alterations of the waters themselves, no art or power of man, nothing less than the power of the Almighty, could ever have made or found, so long and commodious declivities and channels, for the passage of those waters.

11. The largest rivers of Asia, are, the Hoanho, in China, which is eight hundred and fifty leagues in length; the Jenisca of Tartary, about eight hundred leagues in length, from the lake Selinga to the Icy Sea: the Oby in Siberia, of near eight hundred leagues, running from the lake of Kila into the Northern sea: the Amour in Eastern Tartary, whose course is about five hundred and seventy-five leagues, from its source to its entrance into the sea of Kamtkatska: the Kiam in China, five hundred and fifty leagues in length. The Ganges, one of the most noted rivers in the world, is about as long as the former: it is visited annually by several hundred thousand pilgrims, who pay their devotions to the river as to a God; for savage simplicity is always known to mistake the blessings of the Deity for the Deity himself. Next to this may be reckoned the celebrated river Euphrates: this rises from two sources northward of the city of Erzerum in Turcomania, and unites about three days journey below the same; from whence, after performing a course of five hundred leagues, it falls into the Gulf of Persia. The river Indus, is extended, from its source to its discharge into the Arabian sea, four hundred leagues.

The largest rivers of Africa, are, the Senegal, which runs a course of eleven hundred leagues; and the celebrated river Nile, said to be nine hundred and seventy leagues from its source in Upper Ethiopia, to its opening into the Mediterranean sea.

The river, which the natives call Abava, that is, the father of rivers, rises first in Sacala, a province of the kingdom of Goiama, the most fruitful in all Abyssinia. In the eastern part of this province, on the declivity of a mountain, are two springs, each about two feet

in diameter, a stone's cast distant from each other, which are the real source of this celebrated river. Its waters, after the first rise, run east about a musket-shot; then turning to the north, continue hid in the grass and weeds, for about a quarter of a league, and discover themselves for the first time among some rocks, a pleasing sight to those who have read the fabulous accounts of the ancients. It flows thence with a very small stream, but soon receives such an increase from various rivulets, that not above three day's journey from its source, it is near a mile broad. After running nine or ten leagues farther, it enters the lake of Dambia. It crosses this at one end, with such rapidity, that the waters of the Nile may be distinguished through the whole passage, which is six leagues. Fifteen miles farther it rushes from the top of a high rock, and forms one of the most beautiful cascades in the world. The fall of this mighty stream from so vast a height, makes a considerable noise. Yet the neighbouring inhabitants are not deaf, but hear just as well as others. After this cataract, the Nile again collects its scattered stream, and flows on through various nations. Hence we may learn, that it is impossible to arrive at the source of the Nile, by tracing its channel from the mouth, there being so many cataracts in the way, which no vessel can pass.

In Abyssinia, from June to September, there is no day without rain. Now the Nile receives in its course all the brooks, rivers, and torrents, which flow from the Abyssinian mountains. These necessarily swell it above the banks, and fill the plain of Egypt with the inundation. This comes regularly in the month of July, that is, three weeks after the beginning of the rains in Ethiopia.

The water of the Nile is so delicious, that the Turks excite themselves to drink of it by eating salt. When the Egyptians leave their country, they speak of nothing but the pleasure they shall find at their return, in drinking the Nile water. All those who have tasted of it, allow, that they never met with the like in any other place. In truth, when one drinks of it the first time, it seems (says Maserier) to be some water prepared by art. It has something in it inexpressibly agreeable and pleasing to the taste. But to some, it appears to have too much sweetness. It is likewise salutary in the highest degree. Drink it in what quantities you will, it never incommodes you.

It seems peculiar to the water of the Thames, that in eight months' time it acquires a spirituous quality, so as to burn like spirits of wine. Even when it stinks, it is not unwholesome: men who were obliged to hold their noses, yet drank of it all the way to the East-Indies, and found no inconvenience. If you take out the bung from any cask that stinks, and let the air come in, it will be sweet in twenty-four hours.

If you take a broomstick, and stir it well, it will be sweet in four or five hours. It casts a black lee to the bottom, which remixing with it, causes a third or fourth fermentation, after which it stinks no more. But though Thames water does not putrefy when it stinks, many other waters do, and are at that very time dangerous to drink.

The cataracts of the Nile are probably less remarkable than that of Niagara, in Canada. The fall of this is about six leagues from Fort Niagara. The river, for two leagues and a half below the great fall, flows in a narrow passage between the stupendous banks, having its smooth surface frequently interrupted by whirlpools, which ingulf every thing that comes within their influence. The rocks of the great fall cross the river in almost a semicircle. Above the fall, in the middle of the river, and parallel with the sides of it, is an island above four hundred yards long. The lower end of this island is just at the perpendicular edge of the fall. On both sides of this island runs all the water that comes from the lakes of Canada, which indeed are rather seas than lakes, receiving many large rivers. When the water approaches the island, it runs with an amazing swiftness, and before it comes to the fall, is quite white, and in many places is thrown high into the air. Looking up the river from the fall, you see it is exceeding steep, resembling the side of a hill. When this vast body of water comes to the fall, it throws itself down perpendicularly. To see this rush headlong down so prodigious a precipice, strikes the beholder in a manner not to be expressed.

It falls one hundred and sixty feet. When the water is come down to the bottom, it leaps back to a great height in the air: at a little distance it is white as snow, and boils like a cauldron. The noise of it in fair weather is heard many leagues. From the place where the water falls, abundance of vapour rises, resembling a very thick smoke. When it is calm, this rises high in the air. If you go into this vapour, in a few minutes you will be as wet as if you had been under water. In a calm morning, you will see it rising in the air, at a distance of many leagues.

But of all parts of the world, America supplies the largest rivers. The foremost of these is the great river of Amazon, which from its source in the lake of Lauricocha, to its discharge into the Western Ocean, performs a course of more than twelve hundred leagues.—The breadth and depth of this river are answerable to its vast length; and where its width is more contracted, its depth is augmented in proportion. Next to this is that of St. Lawrence, in Canada, which after a course of nine hundred leagues, pours its collected waters into the Atlantic Ocean. The river Mississippi is more than seven hundred leagues in length. The river Plata is more than eight

hundred. The river Oronoko is seven hundred and fifty-five leagues in length, from its source to its discharge into the Atlantic Ocean.

The glory of other rivers increases in proportion to the length of their course. With the Rhine it is quite the reverse. For some hundred miles it pours on with a vast force. But at fort Scheneken it divides, and one half of its waters takes the name of Wahall. The Yssel robs it of another part, a little above Arnheim. About twenty miles lower, at the town of Duerstadt, it separates again. Here its principal branch takes a new name, and is called the Leck. The poor, little, stripped rivulet turns to the right, retaining still the old name of Rhine, and passes on to Utrecht, where it is divided a fourth time. There the Vetcht breaks off, and the little thread of water, still called the Rhine, passes quietly to Worden. At length it comes to Leyden, and faintly finishes its course, by losing the small remainder of its waters in two or three canals.

The cause of the Rhine's fate is well known. It was an earthquake which shook the Downs, in the ninth century, and filling the mouth of this river, forced it to return, and seek a new passage.—The Leck was then scarce worth notice: but the waters of the Rhine, which were driven back, swelled and deepened its channel: and the entrance of the sea has been ever since shut against the ancient course of the Rhine. It is supposed, that Zealand was then divided into the several islands we see now: and that those lands, woods and meadows, which were between Amsterdam and the Texel, were overflowed and covered with the waters still remaining, and known by the name of the Zuyder Sea.

The lake Baiacal, in Siberia, is the greatest fresh water lake yet discovered. It extends in length to above five hundred leagues, and is from twenty-five to eighty leagues in breadth. It is every where deep and navigable. The water is extremely clear, and abounds with fine fish. It receives abundance of rivers, but none runs out of it, besides one, the Angara.

Salt lakes are common in many parts of Siberia. Some contain a pure, white salt, fit for use, which in summer is crystalized by the heat of the sun, and forms a crust on the top of the lake. Springs of salt water sometimes rise in the midst of fresh water. One of these rises through a rock, in the bed of the river Angara. Thirty leagues above this, there is a hill thirty fathom high and two hundred and ten long, consisting entirely of rock salt. There are some lakes, which were fresh some years since, but are now salt: some have by degrees dried up; others appear, where formerly it was dry ground. And some of these, which at first had no fish, are now plentifully stocked

therewith. The natives say, ducks and other birds that live upon fish, carry their eggs from one lake to another.

Three leagues east of Damascus is a lake ten or twelve leagues long, and five or six broad. This continually receives the waters of many rivers; yet never overflows its banks. Above thirty leagues from it there is a river, which is called the Dog river. From under a large vaulted rock, through an opening of twelve or fifteen feet high, and twenty or twenty-five broad, issues continually a vast body of water, which gives rise to this river. And it is the common opinion, that this body of water, comes from the lake, through a subterraneous channel: which is the more probable, because the water of the lake and the river have the same qualities, and contain the very same sorts of fish, being cold, hard, and remarkably unwholesome.

Far different from this, is the water which rises out of the ground, throughout the vast sandy deserts of the Mongal Tartars. Wherever you dig, there rises fresh water. Were it not for this, they must have been altogether uninhabited, either by man or beast. It seems these springs are produced by the rains and melted snow in the spring. For the water sinking in the sand is thereby prevented from exhaling by the heat of the summer sun, which must be very scorching in these deserts, wherein there is not the least shade to be found.

Besides the rivers which run upon the surface of the earth, there are many which hide themselves in its bowels, and run in subterraneous ducts, till they discharge themselves into the sea. A remarkable one of this kind has been discovered on the coast of Languedoc.—There are also several of this sort on the coast of Croatia, opposite Venice.

Thus does the all-wise Creator shower down his treasures on the summits of the mountains, which afterwards diffuse their refreshing streams over the plains below, give life and verdure to the trees and herbs, and beautify and enrich the whole earth. At the same time we see the communication between those parts of nature, that before seemed to have no relation to each other. Indeed all nature is linked together by one law of harmony, which sufficiently proves it to be the work of one wise and gracious Author.

How delightful an object is a large and majestic river! How graceful an appearance does it make in the works of nature! Consider its progress. At first it is but a vein of water, streaming from some hill, and even the scattered pebbles interrupt its course, till it unites with other kindred streams, and then rushes on the plain below. By its fall it hollows the ground, casting it up on each side: then it pursues

its course, eating a passage through every thing that opposes it.—When it has received the supplies of many rivulets, it is dignified with a name. Thus enlarged, it makes the tour of hills and mountains, and at once adorns and enriches the plains.

It has been conjectured by some that at the deluge, the main islands of the globe were formed. It is certain others have been formed in later ages: partly by the casting up of vast heaps of clay, mud and sand, as that of Isongming in the Chinese province of Nanquin, partly by the violence of the sea, tearing off large provinces from the continent. So the ancients imagined Sicily to have been formed, and even Great Britain and Ireland. It is certain also, that others have emerged out of the sea, as Santorini formerly: and three other islands near it lately. The last of these rose in 1707, from the bottom of the sea, just after a violent earthquake. Indeed earthquakes, storms and inundations, have given rise to many islands: particularly in the East-Indies, where they are very frequent, and which abounds in islands above any part of the world.

12. The entire basin of the sea, is of such immense extent, and covered in many places with such an unfathomable depth of water, that it cannot be traced in every part: but from some, we may form a probable judgment of the rest. The materials which compose the bottom of the sea, must in a degree influence the taste of its waters. Its saltness it undoubtedly derives from mountains of salt which are found there: as bitterness from fossil, coal and other bituminous substances, which are there in plenty. There may likewise be many other substances, which the plummet does not discover. For the true bottom of the sea is often concealed by another accidental bottom, formed of various substances mingled together, and covering it to a considerable depth.

The entire gulph of Lyons forms a bank above the surface of the water at the shore, of the exact figure of an arch. And within this there is formed another such arch, making the bottom of the sea, for a great way from shore, of different depths in various places, but generally between sixty and seventy fathoms.

In general the bed of the main sea sinks, about as high as the mountains rise on the land. Near the land, in proportion to the height and steepness of the shores, the sea is deep below. And on the contrary level shores denote shallow seas.

By the strata on the shores we may commonly judge of the bottom of the adjacent seas. For the veins of salt and bitumen doubtless run on in the same order as we see them at land. And the strata of stone that serve to support the hills and elevated places on shore, serve also, in the same continued chain, to support the waters of the

sea.* Probably the veins of metals and minerals likewise, which are found in the neighbouring earth, are in the same manner to be found in the bottom of the sea.

But the natural surface of the bottom of the sea, is greatly changed by subterranean currents. As we see these break out in rivers, on the surface of the earth, so we may be assured they break out at the bottom of the sea, and empty their fresh waters into the salt mass.—In this case the continual rushing up of the water, makes a roundish cavity. And its running on, continues that cavity, till by degrees it is lost. Thus every river that rises in the bottom of the sea, when the water near the shore is clear, shews the traces of these currents, even to the naked eye, and the water taken up from them is more or less fresh.

Again. The coral fisheries give us occasion to observe, that there are many large caverns in the bottom of the sea, especially where it is rocky, as also in the sides of perpendicular rocks. These are often of great depth as well as extent, some with wide, others with narrow entrances. Nor is it any wonder, that we daily find vast cavities in the rocky mountains, so we should find them in the rocks under the sea. Nay, we may expect them in these the rather, as the rocks at land are in a state of rest, while those at sea are continually washed by the water, which insinuates every where, and by its continual agitation, enlarges every cavity it finds.

Upon the whole, it seems plain, that the basin of the sea was after the flood composed of the same substances, as the surface of the rest of the earth, namely, stone, clay, sand, and the like. It is true, the plummet in sounding usually brings up a matter composed of mud, dead weeds, broken shells, and various bodies cemented together by a sparry or tartareous substance. But these are only an artificial bottom, covering the natural one, such indeed as one might expect where numerous animals and vegetables are produced and decay, and where the quiet waters have time to deposit their stony matter as our petrifying springs do.

* The question whether the earth supports the waters or the waters support the earth: or whether air is not the foundation of both, would all be lost in a reflection, on the progressive degrees of density to the centre of revolving motion. For by prosecuting the query, we should find, that matter in all its modes of concretion, aggregation, or composition, might be rendered equally dense. Even one description of earth is more dense than another as metals are heavier than soils; water may be so dense as to suspend every known description of earth; and air may be so condensed as to concenter through both. Hence the true philosophical expression would appear to be, matter in its different grades of density, and in its alternate forms; and it would be, the earthyform, aqueform, or aireform state of matter, in all the grades of density, capable of occupying every station from the centre, to the utmost circumference of the globe.

There are places however where this adventitious crust is not found, but the natural bottom appears of the same nature with the strata in the body of the earth. But the fine and pure sand we sometimes find, seems not to be the original bottom, but to have been rather brought into the sea by the course of some subterraneous river, and to be lodged in one of those particular basins, which these rivers form to themselves.

In deep water, where the surface is only disturbed by storms and the lower part remains more quiet for ages, the bottom is covered with a great variety of things, sometimes with pure sand, sometimes a sort of sand made of shells beat to powder, sometimes with powdered corals, sometimes fragments of rocks. But besides these, which might well be expected, the plummet sometimes brings up substances which are of the most beautiful colours: of as fine scarlet, purple, or blue, as the finest paint could make them. Those of a bright yellow are very common; but the green or snow-white more rare. These coloured substances seem sometimes to make up the whole bottom. But they are more frequently found on other things, as upon mud, corals, or larger pieces of shells, in the manner of tartareous crusts. And their colours are not merely superficial or transient; but many of them are so permanent, that they may be preserved in white wax, and when thus examined, appear equal to paints of the finest kind.

There is very little difference between the bottom of the Adriatic sea, and the surface of the neighbouring countries. There are at the bottom of the water, mountains, plains, valleys, and caverns, just as upon land. The soil consists of different strata planted one upon another; and for the most part corresponds to those of the rock, islands, and neighbouring continents. They contain stones of different sorts, minerals, metals, various petrified bodies, pumice-stones, and lavas, formed by volcanoes. Istria, Dalmatia, Albania, and other adjacent countries, as well as the rocks, the islands, and the bottom of the Adriatic sea, consist of a mass of white marble, of an uniform grain, and of almost an equal hardness. This vast bed of marble in many places under both the earth and the sea, is interrupted by several other kinds of marble, and covered by a great variety of bodies. The variety of these soils under the sea is remarkable: it is to this are owing the varieties of plants and animals found at the bottom of the sea. Some places are inhabited by a great number of different species of plants and animals, in others only some particular species are found, and in others neither plants nor animals. These observations not only point out to us the resemblance between the surface of the earth, and the bottom of the sea, but likewise one cause of the

varieties, which are observed in the distribution of the marine fossils found in the earth.

In the vast mass of marble, which is common to the bottom of the Adriatic, and the neighbouring provinces toward the east, are a multitude of marine bodies petrified; some of which are so united to the stony substance, that they are scarce to be distinguished. Likewise a crust is discovered under the waters in divers places, and for a great extent, which is a composition of crustaceous and testaceous bodies, and beds of polypi of different kinds, confusedly blended with earth, sand, and gravel.

These different bodies which enter into the composition of this crust, are at the depth of a foot or more entirely petrified and reduced into marble. At less than the depth of a foot they approach nearer to their natural state. And at the surface of this crust, they are either dead, though extremely well preserved, or still living.

This demonstrates that stones may be formed from things petrified, and actually are formed, in great quantities under the water. Crustaceous and testaceous bodies and polypi, are every where mingled in the utmost confusion, which shews a striking resemblance between the crust discovered under the sea, and the marine bodies petrified in many parts under the earth.

The more these crustaceous and testaceous bodies and beds of polypi multiply, the more their exuvia, and skeletons contribute to enlarge this crust. In several parts it forms very considerable banks, and of a very great thickness.

It follows that the bottom of the sea is rising constantly higher and higher.* Divers other causes contribute to this; snow and rain, and waters that bring down from the mountains, into the sea, a great quantity of earth and stones. The waves, beating against the continent and islands, detach many masses which are spread upon the bottom of the sea. The rivers carry the mud with their waters into the sea, at the bottom of which that mud deposits itself.

From the rising of the bottom of the sea, that of the level of the water naturally follows. So at Venice, in Istria, in Dalmatia, the level of the waters is several feet higher than it was formerly. This elevation is observed only on the northern and eastern coasts of the Adriatic. The sea seems on the contrary, to abandon the western coast, that of Italy.

The eye can reach but a short way into the depth of any sea, and that only when the surface is glassy and serene. In many seas it per-

* The bottom of the ocean cannot be supposed to rise higher universally, otherwise the waters would attain the same proportionate elevation, allowing an uniform quantity of water appending to our globe; or otherwise the land must rise in the same proportion.

ceives nothing but a bright sandy plain at bottom, extending for several hundred miles. But in others, particularly in the Red Sea, it is very different: the whole bottom of this extensive bed of water, is a forest of submarine plants, and corals formed by insects for their habitation: sometimes branching out to a great extent; so that some have even supposed the sea to have taken its name from the colour of its plants below. However, these are not peculiar to this sea, as they are found in great quantities in the Persian gulf, along the coasts of Africa and those of Province and Catalonia.

The bottom of many parts of the sea near America presents a very different appearance. This is covered with vegetables, which makes it look as green as a meadow; and beneath are seen thousands of turtles, and other sea animals feeding therein.

Ocean-shells are frequently found very near the surface of the earth, which proves that such places formerly have been the sea shore. Hence it is clear, that the cause which transported them thither, acted suddenly, which perfectly agrees with the account of the deluge given by Moses.

Nay, at Touraine, in France, more than a hundred miles from the sea, there is a plain of about nine leagues long, and as many broad, from whence the peasants of the country supply themselves with marle. If they dig deeper than twenty feet, the whole plain is composed of the same materials, which are shells of various kinds, without the smallest portion of earth between them. These shells are in their natural state: but they are found also petrified and almost in equal abundance in all the Alpine rocks, in the Pyrenees, in the hills of France, England and Flanders. Yea, in all quarters from whence marle is dug, if the rock be split perpendicularly down, petrified shells, and other marine substances will be plainly discerned. In several parts of Asia and Africa, travellers have observed these shells in great abundance. In the mountains of Castravan, they quarry out a white stone, every part of which contains petrified fishes in great numbers, and of surprising diversity, in such preservation, that their fins, scales and all the minutest distentions of their make can be perfectly discerned. From all these instances we may conclude that these fossils are very numerous. And the variety of their kinds is astonishing. Most of the sea-shells which are known, and many others to which we are entirely strangers, are to be seen either in their natural state, or in various degrees of petrifaction. But in the place of some we have mere spar, or stone exactly expressing all the lineaments of animals: for the shells dissolving by slow degrees, and the matter having exactly filled all the cavities within, this matter retains the same form which the shells were of.

The greatest depths of the sea ever yet sounded, have been found to be about 3000 fathoms. The ordinary depths are about 150. Though these shells are to be found in almost all the plainer parts of the surface of the earth, yet there are certain very large tracts, where such bodies are never found, viz. the mountains, which seem to be the remains of the original strata of the earth. It is true that there are many eminences which have been taken for mountains, where sea-shells of every kind are found: but these are hillocks, compared with the large mountains, which may be traced into immense chains, without almost any discontinuity, from one continent to another; and from continents to neighbouring and opposite islands: insomuch that all these chains, not only of the old, but likewise of the new world, seem connected one with another. In the Alps, Apennine and Pyreneans, no shells, nor marine bodies of any kind, are to be found: neither in the large Grampian mountains in Scotland.

The same is observed of all the large mountains of Africa, and of Asia, and in the huge chain of Cordilleres in Peru. This kind of mountains, which indeed alone deserve that name, are chiefly composed of vitrifiable matter; and if they are sometimes found to contain sea-shells, it is never to great depths, though such bodies are found in the adjacent valleys.

Potter's earth is found plentifully in most low grounds, and in valleys between mountainous tracts. It would appear wherever this clay is found, as if the earth had undergone some violence by fire, it appearing to be a sediment of vitrified substances, and which as some are of opinion has been effected by earthquakes. It has been thought that the deluge has given origin to many fossil substances, which otherwise would never have existed, among which have been reckoned potter's clay and chalk: limestone also exhibits similar characters.

13. At fixed times the water of the sea runs for near six hours from south to north, which is called the flood, at which time it rises gradually on our shores, and in the channels of the rivers. Then after standing at the same height for a quarter of an hour, it returns for near six hours from north to south, which we term the ebb; and after a quarter of an hour the water rises again. The change thereof is twice in twenty-four hours, but begins near fifty minutes later daily. And this is observed on all the shores of Europe, that are washed by the ocean: whereas the Baltic and Mediterranean sea, as well as the Caspian, have no tides. The nearer we approach the pole, the more impetuous the tides are. The cause of them was wholly concealed from the ancients; but it is now well known to every one. They depend entirely on the motion of the moon, with

which they exactly correspond: the flood beginning to rise just at the time when the moon is in the meridian.*

* The doctrine of attraction is now universally allowed; indeed the whole of the phenomena of nature and of the universe, would be unaccountable and irreconcilable on any other principle: and this attraction is doubtless co-extensive with the universe. There is not a particle of matter in the universe, but has a universal relation, and it is so ordained by the all wise disposer of worlds, that all matter shall be amenable to this sovereign law. But there is one circumstance in the operation of this law which seems to have escaped the notice of philosophers, that is, the particular configuration of bodies under its action, which is the shape of a cone. And this configuration is produced by correspondent motion which is rectilineal from its base to its vertex; or at least as much so as the degrees of density through which it traverses will allow. This particular motion, which more immediately takes place between our globe, the moon, and the sun, and is widely different from the rotatory motion of our globe, is the cause of various phenomena. It is the occasion of the alternate contractions and dilatations of our atmosphere, and this is the origin of the tides, whose greatest rise will be in the greatest curvatures of the globe or rather spheroid. But this tide first takes place in the atmosphere, and the waters of our globe which naturally conform themselves to the motion and figure of the atmosphere, swell in the line of attraction, and thus occasion what we call tides, and these must occur twice in every revolution as we experience them.

If we were subject to no other attractive force than that of the moon, our tides would be uniform: but twice in its orbicular revolution, the line of the moon's attraction coincides with that of the sun. Hence a greater conformation of our atmosphere must take place at these seasons, and hence produce a correspondent expansion of the waters; and this must likewise take place twice in every revolution of the moon in its orbit. These are called spring tides.

Thus originate the phenomena we call tides, from a rectilinear and rotatory motion, if the earth were at rest and devoid of its centrifugal powers, by its rotatory motion on its own axis, it would yield to its rectilinear impetus, and drop into the centre of its attraction, or if it could remain suspended and stationary by any cause, the consequence would be uninterrupted stillness on its surface, and immovable fixidity of its parts. But hence we may trace all the phenomena of nature, and herein we may admire the most matchless wisdom, that hung the world in elastic chains, and swung it as a pendulum to vibrate within the limits of the ecliptic, whence we derive the grateful vicissitudes of the seasons, and by its rotatory motion the accomodation of the periods of time; whence we behold the delightful and magnificient spectacle, of the rising and setting sun, moon and stars, and other celestial phenomena. Hence also the various and incessant motions of the elements, and the active susceptibility of every particle of matter from the centre to the circumference of the globe; for it may be clearly comprehended as a natural consequence, that if the earth was subjected to a solitary uniform motion, all the particles of which it is composed would maintain a correspondent uniformity, and could not subserve the various evolutions which we witness in its diurnal and annual revolutions; and which are a natural consequence of its two great contending propensities to a centrifugal and centripetal direction.

If the globe merely revolved on its own axis, and was not acted upon by other powers, it would be an uniform oblate sphere, but as it is acted upon by other powers, the bulk of the atmosphere is distorted from an uniform spherical figure, to that resembling a cone, and this is the true cause of the tides; for as in the first

There is something remarkable in the manner, wherein the tides rise, in several of our rivers. In the river Severn, in particular, near Newnham, and one hundred and sixty miles from Lundy, the the head of the flood at spring-tides rises in height like a wall, near nine feet high. Thus it pours on for many miles, usually oversetting any vessels that lie in its way. This head-tide they call the Boar; it flows here only two, and ebbs ten hours.

case, if the rotatory motion of the globe was uninterrupted, there could be no tides, so neither could there be any, if the power acting upon it were uniform around it. But as the attractive force acting upon it is on a point of the circumference, and as our atmosphere is dilated to that point, the fluid parts of our globe will consequently become proportionally dilated, every time they revolve to that point. Besides, another consequence must accrue from this, for in proportion as our atmosphere is dilated to the point of attraction, the atmosphere at the poles will be compressed, and flatted, and the line of attraction passing through the earth, and comprehending its entire atmosphere, will have the effect of governing the tide at the opposite point of the globe, by dilating the atmosphere at that point, though in a less degree, and it is observable that the tide is not so great at the opposite point, as at the first immediate point of attraction, for the attraction will decrease in power, in proportion as it increases in distance.

Upon this hypothesis the extraordinary increase of tides towards the poles would be easily accounted for, first from the oblique direction with which the force of attraction it exerted, whereby a greater degree of surface is opposed to the same rectilinear impression, and secondly, from the decrease of the rotatory velocity of the earth towards the poles, whereby the force of attraction is longer exerted on a point. From these considerations it would follow that there could be no perceptible tide at the poles, because their surfaces would coincide with the line of attraction, that the greatest tides would be in those parts of the earth towards the poles, which oppose an oblique surface of forty-five degrees towards the force of attraction; and that they would decrease in an uniform ratio towards the equator, as the globular surface tended to a right angled position with that force.

Thus the phenomenon of the tide might be reduced to mathematical delineation. Numerous observations might be made to corroborate the hypothesis, that the tides are produced by two primary motions of the globe, a rotatory motion on its own axis, and a rectilineal motion towards the centre of the system, in which it is suspended.

I should here proceed to show the force of the rectilinear motion of the globe, and in what manner it was effected and governed. I should also proceed to explain various phenomena which would naturally result from these two primary motions, and which we find by observation and experiment do actually occur. I should show in a particular manner from these data wherein the centrifugal and centripetal forces alternately prevail, and that hence proceeded the eccentricities of the earth's orbit; from these data also I should infer, that the principle which causes the tides, is an universal principle, that it is that principle which connects and suspends worlds at their proper distances, according to their magnitudes and relations, and that the tide we observe in our waters, is but a very, very small proportion of its universal consequence, but these several subjects would introduce me to a vast field for animadversion and calculation, and I feel already forbidden by the length to which this note has extended, I therefore shall conclude it, by alleging as an apology, a solicitude to contribute a serviceable mite to the stock of science.

But how shall we account for the ebbing and flowing of Laywell, near Torbay? This ebbs and flows many times in an hour. It usually performs its flux and reflux in a minute's time. But it stands two or three minutes after the ebb: so that in the whole, it ebbs and flows about sixteen times in an hour.*

14. Currents in the sea are either natural and general, arising from the daily rotation of the earth on its axis, or particular, or accidentally caused by the waters being driven against promontories, or into gulfs and straits, where, wanting room to spread, they are driven back, and so disturb the ordinary flux of the sea.

The currents are so violent near the line, where the motion of the earth is the greatest, that they carry vessels swiftly from Africa to America, but prevent their returning the same way. So that they run as far as the fortieth degree, to find a passage into Europe.

In the straits of Gibraltar, which are about twenty miles broad, the current almost always runs eastward. And so it usually does in St. George's Channel. But the most violent sea is in the straits of Magellan, which is owing to two contrary currents, which meet in those straits.

Sometimes there is an under current, contrary to that above. So it is in the Baltic sound. One of the king's frigates being there, they went with their pinnace in the mid-stream, and were carried violently by the current. Soon after they sunk a basket with a large cannon-bullet to a certain depth of water. This checked the motion of the boat. And when they sunk it lower, the boat was driven ahead against the wind as well as the upper current. And the lower the basket was let down, the stronger the current was found. The upper current appeared by this experiment, not above four or five fathom deep.

And does not the following instance shew that there is an under current at the mouth of the Mediterranean sea? In the year 1712, Mons. l'Aigle, commander of a privateer, chasing a Dutch ship near Ceuta Point, came up with her in the straits between Tariffa and Tangier, and giving her one broadside sunk her. A few days after, this ship with her cargo of brandy and oil arose near Tangier, four leagues west of that place where she sunk, and directly against the strength

* This is a mere local occurrence of the tide, and is unquestionably owing to the local situation of the waters. There are many singularities of tide, which can only be accounted for by average computation. In some long rivers it is high and low water in several places at the same time, and there is not an hour in the day, but it is high water at one place or other. A vessel has been known to sail, and to continue her course with the tide aflood, forty-eight hours together. In some instances the tide has been known to ebb and flow eight times a day, and all this from mere local causes and situations.

of the current. Certainly then the deep water in the middle of the strait, sets outward to the grand ocean. And possibly great part of the water, which runs in at the straits, may run out again that way.

One of the most violent currents in the northern seas, runs between two of the Western Isles. The sea begins to boil, with the tide at flood, and increases gradually, till there are many whirlpools, which form themselves into a sort of pyramids, and immediately spout out as high as the mast of a little vessel. At the same time they make a loud report. These white waves run two leagues before they break. The sea continues these motions till it is more than half flood, and then decreases gradually, till it has ebbed half an hour. From that time it boils again, till it is within an hour of low water. This boiling of the sea is about a pistol-shot distant from the isle of Scarba. But the smallest boat may safely cross the gulf, at the last hour of the flood or of the ebb.

In like manner, the collision of the opposite and oblique streams, near the end of the Orkney islands, excites a circular motion in the water; and when the swiftness of the tide is considerable, occasions whirlpools or cavities in the sea, in the form of an inverted bell, wide at the mouth, and growing gradually narrower towards the bottom. Their width and depth are in proportion to the rapidity of the streams that cause them. Those in Pentland Firth, near the islands Storma and Swona, will, with a spring-tide, turn any vessel quite round.—There have been instances of boats being swallowed up in them. The cavity is largest when it is first formed, and is carried along with the stream, diminishing gradually as it goes, until it quite disappears. The suction communicated to the water, does not extend farther than the cavity. When fishermen are aware of their approach to one of these wells, as they call them, and have time to throw an oar or any other bulky body into it, before they are too near, the spiral motion is interrupted, and the continuity of the water broke; which rushing in on all sides, fills up the cavity, and enables them to go over it safe.

The Maelstroom, is a whirlpool on the coast of Norway, and received this name from the natives, which signifies the navel of the sea; since they suppose a great share of the water of the sea is sucked up and discharged by its vortex. A description of the internal parts is not to be expected, since none ever returned thence to bring information. The body of waters that form this whirlpool, are extended in a circle about thirteen miles in circumference. In the midst of this stands a rock, against which the tide in its ebb is dashed with inconceivable fury. At this time it instantly swallows up all things that come within the sphere of its violence, trees, timber, and shipping. No skill in the mariners, nor strength in rowing, can work

an escape: the sailor at the helm finds the ship first go in a current opposite to his intentions: his vessel's motion, though slow in the beginning, becomes every moment more rapid; and it goes round in circles still narrower and narrower, till at last it is dashed against the rocks, and instantly disappears: nor is it seen again for six hours; till the tide turning, it is vomited forth with the same violence with which it was drawn in. The noise of this vortex increases its terror, which, with the dashing of the waters, and the dreadful valley covered by their circulation, makes one of the most tremendous objects in nature.

May I be permitted to mention here, a cheap and easy way of making sea-water fresh: "I took, says a gentleman, a long glass body, and having filled it with sea-water, put therein sea-weed with its roots fresh and new gathered. Then I put on a head and a beak, and adapted a receiver thereto, without any lute or closing the joints. From the plants distilled daily a small quantity of very sweet and potable water. And probably there may be found other plants near the sea, which would yield fresh water in large quantities."

Sea-water, simply distilled, affords a water as pure and wholesome, as that obtained from the best springs.

From the improvements made by Dr. Hales, it appears that three quarts of water might be procured in five minutes, that is fifty gallons in twelve hours, from a small cylindrical still of Mr. Durand's, by setting some pewter plates edgeways in its head. And a still thirty-two inches in diameter would give two hundred gallons in twelve hours, with only the expense of a bushel and a half of coals.

When sea-water is boiled in a close covered vessel, the steam is converted into fresh water on the inside of the cover. And from a pot of thirteen inches diameter, by frequently removing the cover, and pouring off the water collected upon it, a quarter of a pint of fresh water is procured in an hour.

Perhaps a yet better way of making sea-water fresh, is the following. Take bees-wax, and mould it into the form of an empty hollow vessel; sink the vessel into the sea. The water, in some time will work its way through the pores of the wax, and the quantity contained in the vessel will be fresh, and good for use. The same will happen by using a round earthen vessel, and stopping the aperture: for the water that penetrates it is percolated and pure.

But fresh water may be had in much greater plenty, and more expeditiously, by filling a vessel with river-sand or gravel, and pouring salt-water upon it. The vessel must be perforated at bottom, and by applying a linen strainer, the water, after undergoing a few filtrations, will lose all its brackish taste.

In order to keep fresh water sweet, take of fine, clear, white, pearl ashes, a quarter of a pound of avoirdupois weight, and put it into one hundred gallons of fresh water (observing this proportion to a greater or lesser quantity) and stop up your cask as usual till you have occasion to broach it for use. As an instance of its utility and success, Dr. Butler put an ounce of pearl ashes into a twenty-five gallon cask of Thames water, which he stopt up very close, and let it stand for upwards of a year and a half, opening it once in four months, and constantly found it in the same unaltered condition and perfectly sweet and good: afterwards he made use of it in boiling pease and burgoo, and found that it made the pease as soft, and answered for all purposes to which he applied it, as well as water fresh drawn out of the river.

To this short sketch of what is observable in the terraqueous globe, I subjoin some of the beautiful reflections of Mr. Hervey.

"What an admirable specimen have we here, of the Divine skill and goodness? This globe is intended, not only for a habitation, but for a store-house of conveniences. And if we examine the several apartments of our great abode, we shall find reason to be charmed with the displays both of nice economy and boundless profusion.

"The surface of it, the ground, coarse as it may seem, is yet the laboratory where the most exquisite operations are performed. And though a multitude of generations have been accommodated by it, it still continues inexhaustible.

"The unevennessof the ground, far from being a defect, heightens its beauty and augments its usefulness. Here it is scooped into deep and sheltered vales, almost constantly covered with verdure, which yields an easy couch and agreeable food to the various tribes of cattle. There it extends into a wide, open country, which annually bears a copious harvest: a harvest not only of the principal wheat, which is the staff of our life, but of the appointed barley, and various other grain, which are food for our animals.

"The furrows vary their produce. They bring forth flax and hemp, which help us to some of the most necessary accommodations of life. These are wove into ample volumes of cloth, which, fixed to the mast give wings to our ships. It is twisted into vast lengths of cordage, which give nerves to the crane, and sinews to the pulley, or else adhering to the anchor, secure the vessel even amidst the driving tempest. It covers our tables with a graceful elegance, and surrounds our bodies with a cherishing warmth.

"Yonder arise the hills, like a grand amphitheatre! Some are clad with mantling vines, some crowned with towering cedars, some ragged with misshapen rocks, or yawning with subterraneous caves. And

even those inaccessible crags, those gloomy cavities, are not only *a refuge for wild goats*, but sometimes for *those of whom the world is not worthy*.

"At a greater distance the mountains penetrate the clouds, with their aspiring brows. Their sides arrest and condense the vapours as they float along. Their caverned bowels collect the dripping treasures, and send them gradually abroad by trickling springs: and hence the waters increasing roll down, till they have swept through the most extensive climes, and regained their native seas.

"The vine requires a strong reflection of the sun-beams and a large proportion of warmth. How commodiously do the hills and mountains minister to this purpose! May we not call those vast declivities the garden-walls of nature? These concentre the solar fire, and completely ripen the grape! O that any should turn so valuable a gift of God into an instrument of sin.

"What is nature but a series of wonders! That such a variety of fruits should rise from the insipid, sordid earth! I take a walk through my garden or orchard in December. There stand several logs of wood on the ground. They have neither sense nor motion; yet in a little time they are beautified with blossoms, they are covered with leaves, and at last loaded with fruit. I have wondered at the account of those prodigious engines, invented by Archimedes. But what are all the inventions of men, to those nice automata of nature?

"The forest rears myriads of massy bodies, which though neither gay with blossoms, nor rich with fruit, supply us with timber of various kinds. But who shall cultivate them? The toil were endless. See therefore the ever-wise and gracious ordination of Providence! They have no need of the spade or the pruning knife. They want no help from man.

"When sawed into beams they sustain the roofs of our houses. They make carriages to convey our heaviest loads. Their substance is so pliant, that they are easily formed into every kind of furniture: yet their texture so solid, that they compose the most important parts of the largest engines. At the same time, their pressure is so light, that they float upon the waters. Thus while they serve all the ends of architecture, and bestow numberless conveniences on the family, they constitute the very basis of navigation, and give being to commerce.

"If we descend from the ground floor of our habitation into the subterraneous lodgments, we shall find there also the most exquisite contrivance, acting in concert with the most profuse goodness. Here are various minerals of sovereign efficacy: beds fraught with metals of the richest value: and mines, which yield a metal of a meaner as-

pect, but superior usefulness. Without the assistance of iron, what would become of all our mechanic skill? Without this we could scarce either fix the mast, or drop the faithful anchor. We should scarce have any ornament for polite, or utensil for common life.

"Here is an inexhaustible fund of combustible materials. These mollify the most stubborn bars. They melt even the most stubborn flint, and make it more ductile than the softest clay. By this means we are furnished with the most curious and serviceable manufacture in the world; which admits into our houses the cheering light, yet excludes the wind and rain: which gives new eyes to decrepit age, and more enlarged views to philosophy; bringing near what is immensely remote and making visible what is immensely small.

"Here are quarries stocked with stones, which do not sparkle like gems, but are more eminently useful. These form houses for peace, and fortifications for war. These constitute the arches of the bridge, the arms of the mole or quay, which screen our ships from the most tempestuous seas. These are comparatively soft in the bowels of the earth, but harden when in the open air. Was this remarkable peculiarity reversed, what difficulties would attend the labours of the mason? His materials could not be extracted from their bed, nor fashioned without infinite toil. And were his work completed, it could not long withstand the fury of the elements.

"Here are various assortments and beds of clay, which however contemptible in its appearance, is abundantly more beneficial than the rocks of diamond or the veins of gold: this is moulded into vessels of any shape and size: some so delicately fine as to suit the table of a princess; others so remarkably cheap that they minister to the convenience of the poorest peasant: all so perfectly neat, as to give no disgust even to the nicest palate.

"A multiplicity of other valuable stores is locked up in these ample vaults. But the key of all is given to industry, in order to produce each as necessity demands.

"Which shall we most admire, the bounty or wisdom of our great Creator? How admirable is his precaution in removing these cumbrous wares from the surface, and bestowing them under the ground in proper repositories! Were they scattered over the surface of the soil, it would be embarrassed with the enormous load. Our roads would be blocked up, and scarce any room left for the operations of husbandry. Were they on the other hand, buried at a great depth, it would cost us immense pains to procure them. Were they uniformly spread into a pavement for nature, universal barrenness must ensue: whereas at present we have a magazine of metallic, without lessening our vegetable treasures. Fossils of every kind enrich the bowels, verdure adorns the face of the earth.

"Well then may even the inhabitants of heaven lift up their voice and sing, 'Great and marvellous are thy works, O Lord God Almighty!' And is there not infinite reason for us to join the triumphant choir? Since all these things are to us, not only a noble spectacle, bright with the display of our Creator's wisdom, but likewise an inestimable gift, rich with the emanations of his goodness. 'The earth hath he set before the inhabitants of his glory: but he hath given it to the children of men.' Has he not then an undoubted right to make that tender demand, 'My son give me thine heart!'

"The rocks which bound the sea, are here prodigiously high and strong; an everlasting barrier against both winds and waves. Not that the Omnipotent Engineer has any need of these here. It is true, they intervene, and not only repress the rolling billows, but speak the amazing majesty of the Maker. But in other places the Creator shews, he is confined to no expedient. He bids a bank of despicable sand repel the most furious shocks of assaulting seas. And though the waves toss themselves they cannot prevail: though they roar, yet they cannot pass over.

"Nay, is it not remarkable, that sand is a more effectual barrier against the sea than rock? Accordingly the sea is continually gaining upon a rocky shore: but it is continually losing on a sandy shore, unless where it sets in with an eddy. Thus it has been gaining from age to age, upon the Isle of Portland and the Land's End, in Cornwall, undermining, throwing down, and swallowing up one huge rock after another. Meantime the sandy shores both on our southern and western coasts, gain continually upon the sea.

"Beneath the rocks frequently lies a smooth, level sand, almost as firm as a well compacted causeway: insomuch that the tread of a horse scarcely impresses it, and the waters never penetrate it. Without this wise contrivance the searching waves would insinuate into the heart of the earth; and the earth itself would in some places be hollow as a honeycomb, in others bibulous as a sponge. But this closely cemented pavement is like claying the bottom of the universal canal: so that the returning tides only consolidate its substance, and prevent the sun from cleaving it with chinks.

"Here the main rolls its surges from world to world. What a spectacle of magnificence and terror! How it fills the mind and amazes the imagination! It is the most august object under the whole Heaven. What are all the canals on earth, to this immense reservatory! What are the proudest palaces on earth, to yonder concave of the skies! What the most pompous illuminations, to this source of day! They are a spark, an atom, a drop. Nay, in every spark and atom

and drop, that proceeds from the hand of the Almighty, there is the manifestation of a wisdom and a power absolutely incomprehensible.

"Let us examine a single drop of water, only so much as will adhere to the point of a needle. In this speck an eminent philosopher computes no less than thirteen thousand globules. And if so many thousands exist in so small a speck, how many in the unmeasured extent of the ocean? Who can count them? As well may we grasp the wind in our fist, or mete out the universe with our span.

"Nor are these regions without their proper inhabitants, clothed in exact conformity to the clime: not in swelling wool, or buoyant feathers, but with as much compactness and as little superfluity as possible. They are clad, or rather sheathed in scales, which adhere close, and are laid in a kind of natural oil: than which apparel nothing can be more light, and at the same time nothing more solid. It hinders the fluid from penetrating their flesh: it prevents the cold from chilling their blood; and enables them to make their way through the waters, with the utmost facility. And they have each an air-bladder, a curious instrument, by which they rise to what height, or sink to what depth they please.

"It is impossible to enumerate the scaly herds. Here are animals of monstrous shapes, and amazing qualities. The upper jaw of the sword-fish is lengthened into a strong and sharp sword, with which (though not above sixteen feet long) he scruples not to engage the whale himself. The sun-fish is one round mass of flesh; only it has two fins, which act the part of oars. The polypus, with its numerous feet and claws, seems fitted only to crawl. Yet an excrescence rising on the back enables it to steer a steady course in the waves. The shell of the nautilus forms a kind of boat, and he unfurls a membrane to the wind for a sail. He extends also two arms, with which, as with oars, he rows himself along. When he is disposed to dive, he strikes sail, and at once sinks to the bottom. When the weather is calm he mounts again, and performs his voyage without either chart or compass.

"Here are shoals upon shoals of every size and form. Some lodged in their shell, seem to have no higher employ, than imbibing nutriment, and are almost rooted to the rocks on which they lie: while others shoot along the yielding flood, and range the spacious regions of the deep. How various is their figure! The shells of some seem to be the rude production of chance, rather than of skill or design. Yet even in these we find the nicest dispositions. Uncouth as they are, they are exactly suited to the exigencies of their respective tenants. Some on the other hand are extremely neat. Their structure is all symmetry and elegance. No enamel is comparable to

their polish. Not a room in all the palaces of Europe is so adorned as the bed chamber of the little fish that dwell in the mother of pearl. Where else is such a mixture of red, blue and green, so delightfully staining the most clear and glistering ground ?

" But what I admire more than all their beauty, is the provision made for their safety. As they have no speed to escape, so they have no dexterity to elude their foe. So that were they naked, they must be an easy prey to every free-booter. To prevent this, what is only clothing to other animals, is to them a clothing, a house and a castle. They have a fortification which grows with them, and is a part of themselves. And by means of this they live secure amidst millions of ravenous jaws.

" Here dwell mackrel, herring, and various other kinds, which when lean wander up and down the ocean: but when fat they throng our creeks and bays or haunt the running streams. Who bids these creatures leave our shores when they become unfit for service ? Who rallies and recalls the undisciplined vagrants, as soon as they are improved into desirable food ? Surely the furlow is signed, the summons issued, and the point of re-union settled, by a Providence ever indulgent to mankind, ever loading us with benefits.

" These approach, while those of enormous size and appearance abandon our shores. The latter would fright the valuable fish from our coasts ; they are therefore kept in the abysses of the ocean : just as wild beasts, impelled by the same over-ruling power, hide themselves in the recesses of the forest.

" One circumstance relating to the natives of the deep is very astonishing. As they are continually obliged to devour one another for necessary subsistence, without extraordinary recruits, the whole watery race must soon be totally extinct. Were they to bring forth no more at a birth than land animals, the increase would be far too small for the consumption. The weaker species would soon be destroyed by the stronger, and the stronger themselves must soon after perish. Therefore to supply millions of animals with their food, and yet not depopulate the watery realms, the issue produced by every breeder is almost incredible. They spawn not by scores, but by millions: a single female is pregnant with a nation. Mr. Lewenhoek counted in an ordinary cod 9,384,000 eggs. By this amazing expedient, constant reparation is made, proportionable to the immense havoc.

" And as the sea abounds with animal inhabitants, so it does also with vegetable productions: some soft as wool, others hard as stone.—Some rise like a leafless shrub, some are expanded in the form of a net: some grow with their heads downward, and seem rather hanging on, than springing from the juttings of the rocks. But as we know few particulars concerning these, I would only offer one remark in

general. The herbs and trees on the dry land are fed by the juices that permeate the soil, and fluctuate in the air. For this purpose they are furnished with leaves to collect the one, and with roots to attract the other. Whereas the sea-plants, having sufficient nourishment in the circumambient waters, have no need to detach roots into the ground, or forage the earth for sustenance. Instead, therefore, of penetrating, they are but just tacked to the bottom, and adhere to some solid substance only with such a degree of tenacity, as may secure them from being tost to and fro by the agitation of the waves.

" We see from this and numberless other instances, what diversity there is in the operations of the great Creator. Yet every alteration is an improvement, and each new pattern has a peculiar fitness of its own.

" Considered in another view, the sea is that grand reservoir, which supplies the earth with its fertility: and the air and sun are the mighty engines, which work without intermission, to raise the water from this inexhaustible cistern. The clouds as aqueducts convey the genial stores along the atmosphere, and distribute them in seasonable and regular proportions, through all the regions of the globe.

" How hardly do we extract a drop of perfectly sweet water from the vast pit of brine? Yet the sun draws off every moment millions of tons in vaporous exhalations, which being securely lodged in the bottles of heaven, are sent abroad sweetened and refined, without the least brackish tincture, or bituminous sediment; sent abroad upon the wings of the wind, to distil in dews and rain, to ooze in fountains, to trickle along in rivulets, to roll from the sides of mountains, to flow in copious streams amidst burning deserts and through populous kingdoms, in order to refresh and fertilize, to beautify and enrich every soil in every clime.

" How amiable is the goodness, how amazing the power, of the world's adorable Maker! How amiable his goodness, in distributing so largely what is so extensively beneficial! That water, without which we can scarce perform any business, or enjoy any comfort, should stream by our houses, start up from the ground, drop down from the clouds; should come from the ends of the earth, to serve us, from the extremities of the ocean! How amazing his power! That this boundless mass of fluid salt, so intolerably nauseous to the taste, should be the original spring which quenches the thirst both of man and every animal! Doubtless the power by which this is effected, can make 'all things work together for our good.'

" Vast and various are the advantages which we receive from this liquid element. The waters glide on its spacious currents, which not only cheer the adjacent country, but by giving a brisk motion to the air, prevent the stagnation of the vapours. They pass by large

cities, and quietly rid them of a thousand nuisances. But they are also fit for more honourable services. They enter the gardens of a prince, float in the canal, ascend in the Jet d'Eau, or fall in the grand cascade. In another kind they ply at our mills, toil incessantly at the wheel, and by working the largest engines, take upon them an unknown share of our fatigue, and save us both labour, time and expense.

"So forcibly do they act when collected. And how do they insinuate when detached? They penetrate the minutest tubes of a plant, and find a passage through all its meanders. With how much difficulty does the labourer push his way up the rounds of a ladder? While these carry their load to a much greater height, and climb with the utmost ease. They convey nourishment from the lowest fibres that are plunged in the earth, to the topmost twigs that wave amidst the clouds. Thus they furnish the whole vegetable world with necessary provision, by means of which 'the trees of the Lord are full of sap, even the cedars of Lebanon, which he hath planted.' And notwithstanding their vast elevation and prodigious diffusion, not a single branch is destitute of leaves, nor a single leaf of moisture.

"Besides the salutary and useful circulation of the rivers, the sea has a motion no less advantageous. Daily for five or six hours, it flows towards the land, and for the same time, retires to its inmost caverns. How great is the power that protrudes to the shores such an inconceivable weight of waters, without any concurrence of the winds, often in direct opposition to them! Which bids the mighty element revolve with the most exact punctuality! Did it advance with a lawless and unlimited swell, it might deluge whole continents. Was it irregular and uncertain in its approaches, navigation would be at a stand. But being constant in its stated period, and never exceeding its appointed bounds, it does no prejudice to the country, and serves all the ends of traffic.

"Is the sailor returned from his voyage? The flux is ready to convey his vessel to the very doors of the owner, without any hazard of striking on the rocks, or of being fastened in the sands. Has the merchant freighted his ship? The reflux bears it away with the utmost expedition and safety. Behold, O man, how highly thou art favoured by thy Maker! 'He hath put all things in subjection under thy feet. All sheep and oxen, all the beasts of the field: the fowls of the air, and the fishes of the sea.' Yea, the surges of the sea are subservient to thee. Even these, wild and impetuous as they are, are ready to receive thy load, and like an indefatigable beast of burden, carry it to the place which thou choosest.

"What preserves this vast flood in perpetual purity? It receives the refuse and filth of the whole world. Whatever would defile the land

and pollute the air, is transmitted to the ocean. How then is this receptacle of every nuisance kept clean, kept from contracting a noisome and pestilential taint? It is partly by its incessant motion, and partly by its saltness. By the one it is secured from any internal principle of corruption; by the other it works itself clear of any adventitious defilement.

"Consider the sea in another capacity, and it connects the remotest realms of the universe, by facilitating the intercourse, between their respective inhabitants. The ancients indeed looked on the ocean, as an impassable gulph. But we find it just the reverse: not a bar of separation, but the great bond of union. For this purpose it is never exhausted, though it supplies the whole earth with rain: nor overflows, though all the rivers in the universe are perpetually augmenting its stores. By means of this we travel farther than birds of the strongest pinions fly. We cross the flaming line, visit the frozen pole, and wing our way even round the globe.

"What a multitude of ships are continually passing and repassing this universal thoroughfare! Whole harvests of corn, and vintages of wine, lodged in volatile store-houses, are wafted by the breath of Heaven, to the very ends of the earth: wafted, enormous and unwieldly as they are, almost as speedily as the roe bounds over the hills.

"Astonishing, that an element so unstable, should bear so immense a weight! That the thin air should drive on with such speed those vast bodies, which the strength of a legion could scarce move! That the air and water should carry to the distance of many thousand miles, what the united force of men and machines could scarce drag a single yard! 'Great and marvellous are thy works, O Lord God Almighty!'

"How are the mariners conducted through this fluid common, than which nothing is more wide or more wild! Here is no tract, no posts of direction, nor any but where the traveller may ask his way. Are they guided by a pillar of fire? No, but by a mean, and otherwise worthless fossil. Till this surprising stone was discovered, ships crept timorously along the coasts. But this guides them, when nothing but skies are seen above, and nothing but seas below. This gives intelligence that shines clear in the thickest darkness, and remains steady in the most tempestuous agitations. This emboldens us to launch into the heart of the ocean, and to range from pole to pole.

"By this means are imported to our islands the choice productions of every nation under Heaven. Every tide conveys into our ports, the treasures of the remotest climes. And almost every private house in the kingdom, is accommodated from the four quarters of the globe. At the same time that the sea adorns the abodes of the rich, it employs the hands of the poor. What a multitude of people acquire a

livelihood, by preparing commodities for exportation! And what a multitude by manufacturing the wares imported from abroad! Thus, though it is a false supposition, that the waters themselves are strained through subterranean passages into the inland countries, yet it is true, that their effects are transfused into every town, every hamlet, and every cottage."

I beg leave to insert here what could not properly come in under any of the preceding articles.

It is a curious remark, which Dr. Cheyne makes concerning fluids in general. "I take notice, first of the fewness of the original fluids, in respect of the vast number of the compound ones. The primary ones hitherto known are only four: air, water, mercury, and light, three of which are seldom much compounded with others; so that it is water alone, that is the basis of all our mixtures.* It is the parts of solid bodies floating in this fluid, that produce all our delightful and useful varieties of liquors: so frugal is nature in principles, and so fruitful in effects and compositions. Take notice, 2dly, Of the great difference between the specific gravities of our fluids, mercury being eight thousand times heavier than air. Now not to mention the many uses of this last fluid in artificer's work, had air been as heavy as mercury it had been altogether useless in respiration: it had choaked us immediately. And had there not been a fluid of the same weight with mercury, i. e. a collection of exceeding small, heavy spherules, in the present circumstances of mankind, I do not know what a great part of the world would have done. For the wickedness of mankind, has brought many diseases to that degree of malignity, that a thorough cure could scarce be made of them without this fluid. But by the gravity of this, a remedy is provided for all these maladies, which are more than two or three. But that which is most wonderful in these fluids is, 3dly, that universal property, the direction of their pressure upon the sides of the containing vessel. In all fluids of whatsoever kind or nature this pressure is communicated in lines perpendicular to the sides of the containing vessel. And indeed this property of fluids, which is so uniform, is the necessary consequence of the sphericity of their constituent particles."

Now, could any thing but the almighty power of God, have rounded these infinite numbers of small particles? Or could any thing but his

* Water and air, are not now ranked among the elements. They are found by experiment not to be primary, and elementary, but compound bodies, which are perpetually forming and fixing according to the proportions of their constituent elementary components. But light, caloric, mercury, oxygen, and nitrogen, are now considered as primary elements and the components of air and water. Though the characters of some of these are highly doubtful. Mercury as a primary element, exhibits more genuine characters, than any other substance at present known.

divine wisdom have assigned them their true dimensions, their exact weights, and required solidities? We shall allow him to continue in his infidelity, who can demonstrate by what laws of mechanism, all the particles of water were turned of the same diameter, solidity, and weight; and those of air, mercury, and light, turned of different diameters, solidities, and weights from one another; but all of the same diameters, solidities, and weights among themselves. And what a beautiful idea of this fluid do Sir Isaac Newton's later discoveries present us with! Every ray is endowed with its own colour, and its different degree of refrangibility and reflexibility. One ray is violet, another indigo, a third blue, a fourth green, a fifth yellow, a sixth orange, and the last red. And these are the primary and original colours, from the mixture whereof all the intermediate ones proceed; and white from an equal mixture of the whole; black on the contrary, from the small quantity of any of them being reflected; or all of them in a great measure suffocated. So that it is not properly bodies that are coloured, but the light that falls upon them; and their colours arise from their aptitude, to reflect rays of one colour, and transmit all those of another. The prominent little parts, upon their surface, according to their different degree of density and thinness, are apt to reflect back upon our organ, rays of one colour, and of one degree of refrangibility and reflexibility, and to let others pass through their pores. And this one colour too is less or more intense, according as their prominent parts are of different densities. For the first degrees of intenseness, in all the primary colours, seem to arise from the degrees of density and thinness; and the subsequent degrees, from the other different degrees of thickness, or thinness of the prominent little parts of the surfaces of bodies. Light, acts upon bodies by heating, dissolving, and putting their parts into a vibrating motion. Bodies act upon light, in drawing its parts to them, and that in lines perpendicular to their surfaces. And as there may be different degrees of attraction in bodies, which produce their different degrees of elasticity and cohesion, so there must be different degrees of attraction in mediums supposed, to account for their different powers, in bringing the refracted rays nearer to, or farther from, the perpendicular. For it is well know all mediums have not the same refractive virtue. Now what a beautiful, uniform, and simple theory of light is here! This is so very like the frugal simplicity, and yet the manifold variety of nature, that one would be almost tempted to believe it true, were there no experiment to confirm it. We may observe one more instance of the wonderful wisdom of nature, in the propagation of light, viz. That a ray of light in passing from a luminous point, through two differently refracting mediums, to illuminate a given

point, spends the least time (the refracting powers of the several mediums considered) possible; and consequently when a ray passes through one medium, from a luminous point to reflect upon a given point, it takes the shortest way possible. This the geometers have demonstrated. Now is not this an instance of counsel and design? Is not this like the methods of wisdom, which will not spend more time on a thing than just what is necessary to do the business; which will not go about, but take the shortest course possible that will bring it to the place designed?

The islands of Scilly have been so noted among the ancients, one might expect to find among the inhabitants some consciousness of their own antiquity, and of their appearance in history before the other parts of Britain were at all known. But there is nothing of this kind; the inhabitants are all new comers, not an old habitation worth notice, nor any remains of Phœnician, Grecian, or Roman arts, either in town, castle, port, temple, or sculpture.

We are not to think, however, but Scilly was inhabited, and was frequently resorted to anciently, as the old historians relate. All the islands (several of which are now without inhabitants) by the remains of walls, foundations of many contiguous houses, and a great number of sepulchral burrows, shew, that they have been fully cultivated and inhabited.

That they were inhabited by Britons, is past all doubt, not only from their neighbourhood to England, but from the Druid monuments. Several rude stone pillars, circles of stone erect, rock basins: all monuments common in Cornwall and Wales, are equal evidences of the antiquity, religion, and origin of the old inhabitants.

How came these ancient inhabitants then (it may be asked) to vanish, so as that the present have no pretensions of any affinity of any kind with them, either in blood, language, or customs? How came they to disappear, and leave so few traces of plenty, or arts, and no posterity behind them? From two causes, the manifest encroachments of the sea, and as manifest a subsidence of some parts of the land.

The sea is the insatiable monster which devours islands, gorges itself with the earth, sand, clay, and all the yielding parts, and leaves nothing where it can reach, but the skeleton, the bared rock. The continual advances which the sea makes upon the low lands, are plain to all people of observation. What we see happening every day may assure us of what has happened in former times; and from the banks of sand and earth giving way to the sea, and the breaches becoming still more open, and irrecoverable, it appears, that repeated tempests have occasioned a gradual dissolution of the solids for many ages.

Again, the flats which stretch from one island to the other, are plain evidences of a former union between many now distinct islands. The flats between some of them are quite dry at a spring-tide, and men easily pass dry-shod from one island to the other, over sand banks, where, upon the shifting the sands, walls and ruins are discovered frequently, upon which at full sea there are ten or twelve feet of water. All strong arguments that these islands were once one continued tract of land, though now as to their low lands over-run with the sea and sand. History confirms their former union. "The isles Cassiterides (says Strabo) are ten in number, close to one another; one of them is desert and unpeopled, the rest are inhabited." But see how the sea has multiplied these islands! There are now reckoned one hundred and forty. Into so many fragments are they divided, and yet there are left six inhabited. But no circumstance can shew the great alterations, which have happened in the number and extent of these islands, more than this, viz. that the isle of Scilly, from which the little cluster takes its name, is no more at present than a high rock of about a furlong over, whose cliffs hardly any thing but birds can mount, and whose barrenness could never suffer any thing but sea-birds to inhabit it. How then came all these islands to have their general name from such a small and useless plot?

Doubtless Scilly, which is now a bare rock, and separate from the lands of Guel and Brehar, by a narrow firth, was formerly joined to them by low necks of land, being the rocky promontory of one large island now broken into seven. This promontory (at present called Scilly Island) lying westermost of all the highlands, was the first land of all the islands discerned by the traders from the Mediterranean and Spanish coasts, and, as soon as discovered was said to be Scilly, nothing being more usual with sailors, upon their first seeing land, than to call the part by the name of the whole. But when this considerable island called Scilly was broken to pieces, the greatest portions became inhabited, and had first British names, as Brehar, Trescaw, Enmor; but afterwards were called according to the religion of the times, after the names of particular saints. The chief division was entitled St. Mary's, the others dedicated to St. Nicholas, St. Martin, St. Theon, and so on; but this remarkable promontory being in no wise fit for habitation or devotion, was dedicated to no saint, but left to enjoy its ancient name; and notwithstanding the modern christian dedications, sailors went on in their old way. This high land is still called Scilly, and the islands in general are still denominated Scilly-isles.

It must have been a dispiriting circumstance to the old inhabitants, to see the ocean so continually eating away their low lands, in which

they had their treasures of tin, their houses and ports: but this gradual decay was not the only misfortune which attended them. From the island of Sampson, one may see the foundations of stone fences running on in a straight line across the firth, towards Trescaw-isle, till they are hid in the sand; which sand, when it is full tide, has from ten to twelve feet water on it. Now we cannot suppose that the foundation of these fences was laid as low as high water mark: for who could build fences upon so dangerous a level? At a medium we may suppose them to have been laid six feet above the full tide.

Here then we have the foundations, which were six feet above the high-water mark, now ten feet under, which together make a difference as to the level of sixteen feet.

Here then was a great subsidence, which must have been followed by a sudden inundation, and this inundation is likely not only to have destroyed a great part of the inhabitants, but to have terrified others, who survived into a total desertion of their shattered islands. By this means that considerable people, who were the aborigines, and carried on the tin-trade with the Phœnicians, Greeks, and Romans, were reduced to the last gasp. The few poor remains of this desolation, by their necessary attention to food and raiment, must soon have lost sight of their ancient prosperity, and the faint remembrance that was left of what the islands had been before, expired of itself in an age or two, through the indigence of the inhabitants.

That such an inundation has happened here, is still more plain, because these islands are no longer what they were anciently, fertile in tin: nor are there any remains of so many ancient workings as could maintain a trade so greedily coveted by the ancients. But what is become of those mines? How shall this question be answered, but by confessing that the land, in which they were, is now sunk, and buried under the sea?

I am not fond of introducing earthquakes; but where there has been evidently a great subsidence of the earth's surface, can it be accounted for at all without a previous concussion of the earth? And what nature declares in this case, tradition seems to confirm; there being a strong persuasion in the western parts of Cornwall, that formerly there existed a large country between the Land's-End and Scilly, now laid many fathoms under water. Indeed there are no evidences of any ancient connexion of the Land's-End and Scilly. Yet that the cause of that inundation, which destroyed much of these islands, might reach also to the Cornish shores, is extremely probable; there being several evidences of a like subsidence of the land in Mount's-Bay. The principal anchoring place, called a lake, is now a haven or open harbour. The Mount, from its Cornish name

we must conclude to have stood formerly in a wood ; but now at full tide, it is half a mile in the sea, and not a tree near it ; and in the sandy beach betwixt the Mount and Penzance, when the sands have been dispersed by violent high tides, there have been seen the trunks of several large trees in their natural position, the surface of their section worn smooth by the agitation of the water, sand, and gravel, as if cut with an axe, upon which at every full tide, there must be twelve feet water ; so that the shores in Scilly, and the neighbouring shores of Cornwall are concurrent evidences of such a subsidence, and the memory of the inundations, which were the necessary consequences of it, is preserved in tradition : though like other traditions, in proportion to their age, obscured by fable.

That there has been such a subsidence of the lands, belonging to these islands, the present ruins of the islands testify. And this subsidence reached even to Mount's Bay, and laid under water a great part of the low lands then woody, there being now ten feet water ; so that the shores in Scilly and the shores in Cornwall, are equal proofs of such an inundation. When this inundation happened, we know not ; but two pieces of history possibly lead us near the time. In the time of Strabo and Diodorus Siculus, their commerce was in full vigour. "Abundance of tin was carried in carts," says Diodorus Siculus. "But ten islands in all (says Strabo) and nine of those inhabited." The destruction therefore of Scilly must be placed after the time of these authors ; that is, after the Augustan age.

Now Plutarch hints, that the islands round Britain were generally unpeopled in his time. If he includes Scilly among them, then this desolation must have happened between the reign of Trajan, and that of Augustus.

15. At the mouth of the river Ness, near Burgespu in Flanders, at the depth of fifty feet, are found great quantities of trees lying as close to each other, as they do in a wood ; the trunks, the branches, and the leaves are in such perfect preservation, that the particular kind of each tree may be known. About five hundred years ago this very ground was known to have been covered with the sea ; nor is there any history of its having been dry ground, which no doubt must have been the case. Thus we see a country flourishing in verdure, producing large forests, and trees of various kinds, overwhelmed by the sea. We see this element depositing its sediment to the height of fifty feet : and its waters must, therefore, have risen much higher. We see the same after it has thus overwhelmed and sunk the land so deep beneath its slime, capriciously retiring from the same coasts, and leaving it habitable once more. All this is wonderful, and perhaps instead of attempting to inquire after the cause, it will best become us to rest satisfied with admiration.

At the city of Modena, in Italy, and about four miles round it, whenever they dig, when the workmen arrive at the depth of sixty-three feet, they come to a bed of chalk, which they bore with an auger five feet deep. They then withdraw from the pit, before the auger is removed, and upon its extraction, the waters burst up through the aperture with great violence. That which is most remarkable in the operation is the layers of earth, as we descend.* At the depth of fourteen feet are found the ruins of an ancient city, paved streets, houses, floors, and different pieces of mosaic. Under this is found a solid earth, that one would imagine had never been removed; however, under it is found a soft, oozy earth, made up of vegetables: and at twenty-six feet deep, large trees entire, such as walnut-trees, with

* It is found by experience, that the crust of the earth consists of strata or lamella, which serve as veins for the circulation of the various subterraneous effluvias. This agrees with all the experience and observations of miners and diggers of wells, for nothing is more common than for them to say, that one must dig down to such a strata, before he can come at water, air, ore, coal, &c. and they dig accordingly through beds or layers of earth, sand, gravel, clay, stone, marl, &c. and ultimately arrive at the strata which they are in search of; and these layers or strata, are found commonly to extend for many miles. Hence it would appear that this is the method which nature generally observes, in the construction of the globe, whereby one layer is protruded over another, in the manner of scales. This idea would lead us to a pretty clear solution of many phenomena in the operations of nature, particularly if we extended it to the divisions of the atmosphere, which would appear from analogy, with considerable plausibility, and from the manner in which balloons have been found to ascend. These ideas would lead us on in a regular train, to other ideas, which would make it almost appear as if there was a regular circulation of fluids, airs, and gasses, through the body of the globe; something similar to the circulation of the humours in animals, and vegetables; and that while this went on in a regular and uninterrupted course, the equilibrium of nature would be preserved. But if this regularity should be interrupted by any means, congestions, and inflammations, would succeed, as a natural consequence. Might it not appear as if some such like circumstance was a great and principal cause of many and various convulsions in nature. There would not be wanting, numerous circumstances, incident to a miniature body, which exhibit relations strikingly correspondent to the circumstances incident to the great body of the globe itself. Hence we might contemplate a degree of parallelism, between a wart, or excrescence on an animal or tree, and a mountain protruberated on the surface of the earth. A volcano would appear like an ulcerous eruption, and an earthquake as a shaking fit. We might contemplate the surface of the human body, as agreeably diversified with hills and valleys; and the divisions of the strata of the earth would appear like arteries and veins, for the elaboration and circulation of its juices; such as airs, gasses, waters, mineral effluvia, &c. and electrical phenomena taking place, gives motion to the whole. I might here enlarge much on this interesting subject, but circumstances oblige me to retrench observation. Sufficient has been said, to impress an idea, that surprising phenomena may occur from the internal revolutions of the earth, and the external convolutions of the atmosphere; nor would the idea appear foreign to natural consequence, that the evolutions of alternate compres-

the walnuts still sticking on the stem, and their leaves and branches in exact preservation. At twenty-eight feet deep, a soft chalk is found mixed with a vast quantity of shells, and this bed is eleven feet thick. Under this, vegetables are found again with leaves and branches of trees as before; and thus alternately chalk and vegetable earth, to the depth of sixty-three feet. These are the layers whenever the workmen bore; while in many of them they also find pieces of charcoal, bones, and bits of iron. From this description it appears, that this country has been alternately overflowed and deserted by the sea, one age after another: nor were these overflowings and retirings of trifling depths, or of short continuance. When the sea burst in, it must have been a long time in overflowing the branches of the fallen forest with its sediment; and still longer in forming a regular bed

sion, and expansion of the earth's surface do perpetually occur, though in imperceptible degrees, comformably to the abundance or deficiency of its internal circulating matter. Should an expansion of the earth's surface, which constitutes the bottom of the sea, at any time take place, and not far from the land, the consequence would be, that the waters lifted from their bed, would yield to the impetus of gravitation, and pour in a flood proportionate to their extra elevation, upon the shores of the adjacent country, and overwhelm all the accessible parts, whose surface was situated below their elevation. Thus might the various changes and alterations of the earth's surface, be in a considerable degree accounted for; thus might the bottom of the sea be elevated to become dry land, and a habitable country sunk to the bottom of the sea; thus might the surface of the earth, with its cities, fields, and furniture, become a second, third, fourth, fifth, &c. strata of the earth, by the protrusion of various strata over it: and there would consequently be discovered on exploring these strata, the relics of animals, vegetables, and human industry; thus might a fine tillable country be sunk to a morass, and thus might a lake occupy the site of a mountain, and a mountain exalt itself on the bed of a lake. Nor are these wonderful occurrences uncommon; innumerable instances of like phenomena are recorded, and well authenticated; and thousands at present living, have been witnesses to similar awful events. Here I should go on to show that every day's occurrence, furnishes us with ample testimonies of these facts, did we but contemplate the ordinary operations of nature, under proper analysis, and synthesis, but as I have before observed, we are too apt to lose sight of those gradations, with which nature enshrouds her operations, and to content ourselves with contemplating her general plan, and overlook her minute processes; or amuse, and bewilder ourselves with the infinitude of her minutia, and forget her general economy. Thus the want of due system and observation, is a very serious hindrance to our progress in knowledge, and frequently binds the mind fast in the chains of tradition. But probably as formidable a source of ignorance, and error, is the habit of precipitate decision, from hackneyed precept; and I venture to say, that there is not a more common, and stubborn habit than this: and none perhaps so unreasonable, and fatal. A wise man will not judge rashly, and none are so prone to form a hasty judgment, as those who are least able to judge. To ascertain an error well is as instructing as to discover a truth. The subjects in this chapter are principally extracted from the writings of some of the most eminent philosophers, and well attested by the most respectable characters, and are equally interesting, and instructing.

of shells eleven feet thick over them. It must therefore have taken an age, at least, to make any one of these layers; and we may conclude, that it must have been many ages employed in the production of them all. The land also, upon being deserted, must have had time to grow compact, and to be drained of its waters before it could be disposed to vegetation.

Likewise in cutting a channel for the canal of Newry, in Ireland, a great multitude of fallen trees was discovered, lying near two miles in length, and in many places, six or eight feet deep. Many of these are very large, and are tumbled down one over another, some lying in straight lines, and others in an oblique or transverse position. If trees thus found had been felled by the deluge, as undoubtedly others were, they would all lie in one position. But this is not the case. We must therefore seek for other causes. And one cause seems to have been this. If water flowing either from springs or streams be stopt, it naturally softens and loosens the earth; and in a course of time, even to the roots of trees, which are then subject to be overturned by any violent storm. This doubtless was the case with most of those trees that are found in bogs with the roots adhering to them.—Trees thus falling sink into the yielding soil, and cause a farther stoppage in the course of the waters. Hence the loose earth is increased, by a yearly accession of scurf, moss, grass, and weeds. Add to this, that the higher lands being gradually dissolved by repeated rains, and washed down by floods, in a long course of years, cover the lower grounds with fresh layers of earth. This being so, it is not strange to find trees buried eight or ten feet under the earth.

Another cause may be this. Various colonies from time to time arriving in the then uncultivated country of Ireland, would naturally make room for tillage and pasture, by clearing the ground of its forests. This was certainly the case, where we find in bogs, trees partly burned, and others bearing the mark of the axe. But sometimes these colonies were driven by the natives from their intended settlements, leaving the trees they had felled strewed over the plain, which stopping the waters, of course created bogs, that in process of time covered those trees to a considerable depth. Nay, as late as 1561, Tyrone and O'Donnel marching toward Kinsale, through Connaught, and laying the country waste, there is a great tract of ground, now a bog, which was then ploughed land.

That bogs in general grow but slowly may be gathered from a lump of coins of Edward IV. (probably lost in a purse which rotted away) taken up in a bog in Yorkshire, eighteen feet deep. This was about 300 years before. So the bog had grown about a foot in eleven years; that is, somewhat above an inch in a year: although some seem to grow much faster.

Much more ancient is the Great Level, or fenny ground, which contains about 300,000 acres, lying in the counties of Norfolk, Suffolk, Cambridge, the isle of Ely, Huntingdon, Northampton, and Lincoln. This was once firm land. There have been found therein, stones, bricks, and other materials for building. In setting down a sluice, there was found, sixteen feet deep, a smith's forge, and all the tools thereunto belonging. William of Malmsbury, who lived 1200 years ago, says, that in his time "The trees which grew there, smooth and straight, were so tall they seemed to touch the stars. A plain there is, as even as the sea, which, with the green grass, allures the eye: and there is not the least parcel of ground that lies waste and void. Here you see plantations of fruit-trees; there a field set with vines, part creeping on the ground, part mounting on high poles." But how can it be reduced to so very different a state? It seems the ocean broke in upon it, with such resistless violence, that the buildings throughout the whole space were overturned, and the trees torn up by the roots. The amazing quantity of filth thrown up at the same time, covered the whole country, even to the verge of the highlands, seven, eight, and even ten feet deep. Hence, a few years since in digging a pool, there was found at the upper skirts of the level, the skeleton of a large fish, near twenty feet long, lodged in filth above six feet below the surface of the ground. Yet how or when this inundation was, we are not able to determine. Whenever it was, it was probably occasioned by a violent earthquake.

16. A late writer gives the following account of the natural origin of bogs in Ireland. Some of these have vast quantities of timber under them: others have very little. But the surface of all is covered with a short, thick, and matted kind of heath. This as it grows and thickens at the top, vegetates at the bottom into a close texture, which being replete with moisture, throws out annual growths of this ramified heath, part of which dies every winter, and moulders at the bottom, where it forms another stratum, from which at spring comes a new crop of heath. And thus as these strata of mouldered heath are annually repeated, the roots increase, and at once extend higher, and are more consolidated at the bottom. Hence the turf is always found of a closer texture, as we descend deeper in the bog.

The turf is itself only a closely concreted combination of the roots of this heath, which universally grows on the surface of these bogs: not the produce of the trees which are at the bottom. Wherever these were thrown down, some earth would be washed down upon them from the adjacent grounds, the surface of which every where produces this heath. And this being now supplied with constant moisture, would throw out a more plentiful growth.

The same cause produces these bogs on the sides and even tops of mountains. But it is ever in wet grounds, or in flats on the side of hills, where the water settles, and supplies them with moisture.

There seems indeed to be a spongy quality in this heath, which prevents the moistures sinking away from it, by an attraction of the fluids, by an infinite number of capillary fibres, which are the very substance of it. At the bottom of these mountain-bogs, no trees are found. And very few in the largest bogs, unless on the skirts of them.

The turf then from top to bottom is entirely the produce of a vegetation from itself. And the reason why Ireland produces so many turf-bogs, is because it so abounds with the seeds of this heath, which is every where found where the land is uncultivated, and forms bogs, wherever it has proper moisture.

Our marle is found only in the bottom of low bogs, at the depth of seven, eight, or nine feet. For three feet is a spongy sort of earth, then gravel for about half a foot. For about three feet more is a spongy earth, mixed with timber, but so rotten, that it cuts like earth. Next to this for the depth of three inches we find leaves, that are fair to the eye, but will not bear a touch. With these are sometimes mixed heaps of seed, which seem to be broom or furze seed: nay, in one place what seemed to be gooseberries and currants was found, and sea-weed in others. Under this was blue clay half a foot thick, thoroughly mixed with shells, as was also the marle, which lay next, three or four feet deep. They are shells of periwinkles: and among these are large horns and bones answerable thereto. But it is not only in bogs that subterraneous trees are found; nor in Ireland only, but in many parts of England. At Youle, about twelve miles from York, near the place where the Dun empties itself into the Humber, abundance of them have been dug up from time to time; all of which are a species of fir. In the Isle of Axholme, in Lincolnshire, not firs only, but abundance of oaks are found in the moor, whereof some are five yards in compass, with quantities of acorns near them. The first lie somewhat deeper than the oaks: one of them was thirty-six yards long. The adjoining levels (about 180,000 acres) were half of them yearly covered with water, till king Charles I. sold them to Sir Cornelius Vermuyden, who drained them at the charge of above 400,000*l*. In the soil of all this land, through all Marshland, and on the skirts of all the Lincolnshire and Yorkshire wolds, are found millions of roots and bodies of trees, firs, oaks, birch, beech, yew, willow and ash. The roots stand in their natural postures, as thick as ever they could grow. The bodies of most of the great trees lie all their length about a yard from their roots with their tops north-east. The smaller lie across in every direction, some under, some above them. Some

of the oaks are thirty, some thirty-five yards long, yet wanting some yards at the small ends. They are firm, lasting, and as black as ebony. Many of them have been burnt, some quite through, some on one side. Some have been found chopped and squared, some bored through; some half cleft with great wooden wedges in them, and broken axe-heads, shaped not unlike the sacrificing axes. And all these were in such places, and at such depths, as could not have been opened, from the time the forest was destroyed until the ground was drained. Near a great root in the parish of Hatfield, were found eight or nine Roman coins: and at the bottom of a new drain, were found trees squared and cut, rails, bars, a kind of battle-axe, and two or three coins of the emperor Vespasian. Nay, the ground at the bottom of the river was found to lie in ridge and furrow, manifesting that it had been ploughed. In an old drain, an oak was found forty yards long, four yards in diameter, at the great end, three yards and a foot in the middle, two yards at the small end; so that by a moderate computation, it seems to have been as long again. Yea, about fifty years ago, there was found, several feet deep, a man laying at his full length, with his head upon his arm as asleep. His skin, tanned as it were by the moor-water, preserved his shape entire; but his flesh and most of his bones were consumed.

These stately trees formerly composed one of the most beautiful forests in the world. But how came it to be destroyed? When the Romans pursued the Britons, they always fled into the woods. On this the Roman generals ordered them to be cut down; this vast forest in particular. The trees falling across the rivers which ran through the country, soon dammed them up, turned the ground into a lake, and gave rise to the moors, that increased continually, by earthy matter washed down, the consumption of rotting branches and leaves, and the growth of water-moss, which wonderfully flourishes on rotten grounds. Hence it is, that so many Roman coins have been found at the bottom of these levels; that so many trees are found burnt or chopped; and that the soil of the country in general is two, three or more yards higher than formerly.

Some similar alteration seems to have happened, many centuries ago, to that whole tract of land, near Newbury in Oxfordshire, out of which they dig their peat. There is a stratum of this several miles which lies many feet under the surface.

The best peat has very little, if any, earth in it, but is a composition of wood, branches, twigs, leaves, and roots of trees, with grass, straw, plants, and weeds. The colour is of a blackish brown: and if it be chewed between the teeth it is soft, and has no gritty matter in it. It is indeed of a different consistence in different places, some being softer and some harder: which may arise perhaps from the

different sorts of trees it is composed of. Great numbers of trees are visible in the true peat, lying irregularly one upon another, and sometimes even cart loads of them have been taken out: but the nearer these trees lie to the surface, the less sound is the wood; and sometimes the small twigs which lie at the bottom are so firm as not to be easily cut through: these trees are generally oaks, alders, willows, and firs, besides some others not easily known. The small roots are generally perished, but yet have sufficient signs to shew that the trees were torn up by the roots, and were not cut down; there being no sign of the axe or saw, which, had they been felled, would have been plainly visible. A great many horns, heads, and bones of several kinds of deer, horns of the antelope, heads and tusks of boars, and heads of beavers, are also found in it, and some human bones.

Before we dismiss this subject, it may not be improper to subjoin as strange an account as any age can parallel. June 7, 1697, near Charleville in Ireland, a great rumbling was heard in the earth.—Soon after, in the bog of Kapanihane, stretching north and south, some meadow and pasture land, that lay on the side of the bog, separated by a large ditch, and other land, on the further side adjoining it, began to move: and a little hill in the middle of the bog, sunk down.

This was at seven in the evening, the ground fluctuating in its motion, like the waves of the sea. The pasture land then rose up, overran the ground beneath, and moved upon its surface: rolling on with great violence, till it had covered the meadow sixteen feet deep. It drew after it the body of the bog, part of it lying on the place where the pasture land was before, leaving great breaches behind it, and currents of water, which cast up noisome vapours. There are still cracks and chasms through the whole surface of the bog, which contains forty acres.

But we have a later incident of the same kind. On Saturday, January 26, 1745, a part of Pilling Moss, lying near Hescombhouses, was observed to rise a surprising height. After a short time it sunk as much below the level, and moved slowly toward the south side.—In half an hour it covered twenty acres of land. The improved land, adjoining to that part of the bog, is a concave circle, containing near a hundred acres, which is well nigh filled up with bog and water. In some parts, it is thought to be five yards deep.

An intense frost retards its progress for the present, but it is likely to spoil a great deal more land. That part of the Moss, which is sunk like the bed of the river, runs north and south. It is above a mile in length, and near half a mile in breadth.

Perhaps some morasses have been ever since the deluge. In some of these are found, many feet deep, whole forests of timber, and fre-

quently of such sorts as have not grown in those countries for many ages.

But some morasses are only of late date. Lord Cromartic gives a remarkable account, of what he himself observed with regard to the generation of such a morass. In the parish of Lockburn, he saw, near the top of a very high hill, a plain about a mile over. It was then covered with a standing wood, but so old, that the trees had neither leaves nor bark left. When he came by the place fifteen years after, he observed all the trees were fallen. A few years after that, they were quite covered over with a soft, spongy earth, which formed a proper bog or morass. Many have been formed the same way.

The discovery of the bones of elephants at the bottom of some of our English bogs, seems a convincing proof, that the earth has undergone some very extraordinary alterations. For the remains of animals of quite different climates, which, in the present situation of the world, could never possibly come over hither, must imply, their having been originally here, or that England was once joined to the continent. But, since we find these creatures only in the very hot countries, it is highly probable, they were not originally here, unless we suppose the temperature of our climate to have been greatly altered. And without such a supposition, we cannot suppose they would have wandered hither, though all parts of the globe had been contiguous. But what changes have happened to our earth, no human wisdom can find out. Suppose only the axis thereof to have been shifted at any time but a few degrees, what convulsions in nature, what an universal change in the face of things must have ensued! What inundations of water, bearing every thing before them! What breaches in the earth, what hurricanes and tempests, must have attended such an event! For the waters must have rolled along, till an equipoise was produced. And all parts of the world must acquire different degrees of heat and cold from what they had before. Seas would be formed, where continents had been; continents torn in pieces, or split into islands. Such would have been the fate of inanimate things. And as to living creatures, they must have been destroyed and buried in the ruins of the world, as perhaps these elephants were.

NOTE.

THERE is no manner of doubt, but that our globe is subject to perpetual alteration, both in its concrete and fluid states; and that, in the course of several thousand years, it exhibits widely different aspects and characters; not only in consequence of extraordinary concussions and evolutions, but also by gradual and uniform propensity. It is unquestionably subject to periodical vicissitudes, and different eras produce very different consequences. Our records abound with revolutionary events, and we witness many surprising and awful monuments of the ravages of time, and of the elements. If the force of attraction, by virtue of which all the phenomena of our globe occur, was uniform in its operation, it is reasonable to suppose, we should experience a correspondent uniformity of effect. But the globe is subject to alternate augmentation and diminution of attractile forces, in the course of its periodical revolutions; whence we witness extraordinary consequences. When the sun and moon, for instance, are in conjunction, our atmosphere becomes more expanded in the line of attraction, and consequently the waters sustain a proportionate degree of expansion, and this we term spring tide. But it appears that there are other attractile forces, to which our globe is subject; as those of the neighbouring planets, and those of the comets; and in proportion to the number of their conjunctions, extraordinary phenomena may occur; and these effects would naturally take place in succession. First, the atmosphere would yield to the operating force. Second, the waters, and third the fluids entering into the composition of the earth. From all these considerations, we should be led to the following conclusions: that in proportion as the pressure of the atmosphere was diminished, the fluids of our globe would be rendered active; that it is the equable compressure of the atmosphere which governs the fluid parts of our globe, in equable procession and quiescence; that, in proportion as the bulk of our atmosphere is dilated, its rotatory velocity is retarded, which appears to be manifest in the phenomenon of the tide; the accumulation of the waters, at the points of attraction, taking place as a natural consequence. Should the atmosphere be dilated to an extreme degree, the latent fluids would become volatilized, and start from their beds; torrents of gasses would rush from their quiescent abodes, and rend the solid earth in their impetuous courses; or, finding a passage between the strata of the earth, its surface would heave in undulations, as they passed in a linear direction, like the waves of the sea. This is peculiarly observable in South America, where the same shock, as it is termed, is observed to travel longitudinally, the course of the mountains, through immense regions of country; and, in these parts, these phenomena are very frequent.

But there is scarce a district of the earth, where they have not been experienced at one time or other. Europe, Asia, Africa, and America, abound with monuments of their ravages. The fractured surface of the earth, in numerous places, exhibits evident marks of violence from some dreadful concussion in nature; mountains, rocks, caverns, and pits, proclaim the dreadful inroads of desolating power. Nor should we wonder at all this, we see it, in miniature, daily; every breeze, every storm, every flash of lightning, every peal of thunder, advertise a power, which is not only capable of changing the aspect of nature, but of rending the earth to atoms; and hurricanes, tornadoes, volcanoes, and earthquakes, are but these, in an extended degree.

On witnessing the tremendous power of the elements, the boldest skeptic must stand appalled! What dreadful consequences, what awful desolations, result to the fearful violence of an hurricane! Hurricanes, to use the words of Dr. Mosely, cannot be described; like fire, their resistless force consumes every thing in their track, in the most terrible and rapid manner; like the eruption of a volcano, and an earthquake, they are preceded by an awful stillness of the elements, and a closeness and mistiness of the atmosphere, which makes the sun appear red, and the stars larger: but a dreadful reverse succeeds—the sky is suddenly overcast, and wild—the sea leaps from its bed in mountainous heights—the wind rages, and roars like thunder—the rain descends in deluges—a dismal obscurity envelopes the earth with darkness—the superior regions seem rent with lightning—the earth trembles—terror and consternation distract all nature—the birds are carried from the woods into the ocean, and those whose element is the sea, seek refuge on

land—the affrighted animals in the fields assemble together, and are almost suffocated by the impetuosity of the wind, in searching for shelter, which when found, serves only for their destruction—the roofs of houses are carried to a vast distance from their walls, which are beat to the ground, burying their inhabitants in their ruins—the trees are torn up by the roots, and their branches carried aloft in the air, with incredible velocity—every tree and shrub that survives the shock is stript of its foliage—plants and grass are laid flat on the earth, and the luxuriant spring is changed in a moment, to dreary winter. Such are the dreadful ravages of the hurricane, which is deemed less formidable than an earthquake, whereby whole countries are buried, in one fatal moment, in the bowels of the earth, and new surfaces spread over them. From a due consideration of these awful events, we shall cease to wonder at the minor alterations and variations of the earth's surface: we shall cease to wonder, that an upland should be converted into a bog, or that a lowland should be projected into eminences; for these may take place without any sensible shock: we shall cease to wonder, that at different periods of time, mighty revolutions should occur, the aspect of nature be changed, and stamped with all the marks of a new creation, in consequence of the co-operation of such formidable powers. But our wonder will be rather excited, that nature should maintain her equilibrium, and preserve her uniformity, so long, amid such a combat of conflicting elements; and, that more dreadful catastrophes do not more frequently occur.

It is a satisfactory and consolatory conclusion, to the pious mind, that God is the universal architect of worlds; and the idea would not appear inelegant or impertinent, that He has ordained a kind of fraternity, or reciprocity, among them, whereby an interchange of their constituent, elementary principles should be perpetuated: and, pursuing the idea, it would not appear inconsistent, that they should be considered as creatures, subject to origin, growth, maturity, and decay. Hence, it would not appear strange, that a world should be subject to great periodical, and alternate, vicissitudes; or that it should be subject to a redundance, or deficiency, of its component elements; and that in one case, a deluge might destroy it, and in another, its fires might consume it.

It is generally supposed that great changes took place in the earth, in consequence of the general deluge; that a greater proportion of water remained attached to it after, than before, the flood; that the continents were broken, and severed into islands; and that the quantity of dry land was proportionably reduced. It has also been conjectured that the earth became subject to greater vicissitudes of the seasons, and its inhabitants more liable to sickness, and disease; and it has been considered as a reason, that the earth, in consequence of the superabundance of its waters, is subjected to greater degrees of evaporation, moisture, and exhalation; and that the elements are thrown into greater agitation. And these circumstances are considered by some as the source of the general calamities that befall mankind; that, in consequence of these great changes, the years of his life are reduced to a smaller number, and he, and all living creatures with him, rendered the remediless victims of affliction and sorrow. Whatever degree of plausibility may be considered as attached to this doctrine, one thing is most certain, and that is, that man, by his own folly and imprudence, is his own greatest punisher; and if the world itself were better, it would make no great difference to him, unless he himself were better also.

END OF VOLUME FIRST.

CONTENTS

OF THE FIRST VOLUME.

INTRODUCTION.

OF THE GRADUAL IMPROVEMENT OF NATURAL PHILOSOPHY.

1. The order observed in this treatise 11
2. The method of Philosophising among the Hebrews and Egyptians ib.
3. Among the Greeks; the Philosophy of Pythagoras, Plato, Aristotle ib.
4. The different method pursued by the four Greek sects ib.
5. The philosophy of the schoolmen 12
6. The revival of philosophy by Lord Bacon ib.
7. Greatly promoted by philosophical societies ib.
8. The improvement made in every branch of it: in anatomy; the discovery of the circulation of the blood, of the lacteal veins, and the thoracic duct ib.
9. Of the generation of all animals from eggs ib.
10. Of the transfusion of blood 13.
11. Diseases themselves and the operations of medicines give occasion for farther discoveries ib.
12. Many anatomical discoveries have been made by microscopes 13
13. Many, with regard to brutes, particularly fishes and insects ib.
14. Many likewise, with regard to plants, stones, metals, and minerals ib.
15. Great improvements from the art of chemistry. 14
16. Discoveries concerning the loadstone ib.
17. Concerning glass and burning-glasses ib.
18. The nature of the air is more accurately discovered by means of the barometer, the thermometer, and the air-pump ib.
19. Discoveries relating to water ib.
20. Discoveries which shew the nature of fire: of gun powder, phosphorus, aurum fulminans 15
21. Important discoveries of modern astronomy ib.
22. Hence the advantages of the present age ib.
23. Of spirits and divine things ib.

PART THE FIRST.

OF MAN.

CHAPTER I.

OF THE STRUCTURE OF THE HUMAN BODY.

1. The similar, solid parts 17
2. A fibre ib.
3. The cellular membrane 20
4. A bone 22
5. A cartilage 24
6. A membrane 25
7. An artery ib.
8. A vein 27
9. The lymphatic vessels, and their use 28
10. A nerve ib.
11. The flesh 29
12. A gland ib.
13. A muscle ib.
14. The cuticle or scarf skin ib.
A boy with a dappled skin 32
15. The fat 36

16. The panniculus carnosus 37
17. The dissimilar parts; in particular the head, cerebrum, cerebellum, medulla oblongata ib.
18. The meninges 38
19. The brain ib.
20. The origin of the nerves ib.
21. The pineal gland 39
22. The guards of the eyes 40
23. The muscles of the eye; the tunica adnata, the structure of the eye ib.
24. The coats of the eye 41
25. The humours of the eye ib.
26. Peculiarities relative to the eyes; help for decayed sight; account of a person couched 45
27. Queries concerning the eyes 46
28. The external parts of the ear ib.
The internal, particularly the drum 47
29. The bones, passages, windows, labyrinth ib.
30. The nostrils 49
31. Of the tongue ib.
A person speaking without a tongue 50
Persons deaf and dumb taught to speak ib.
Dumbness suddenly removed 51
Of the teeth ib.
32. The palate 52
33. The uvula, tonsils and windpipe 53
34. The hair ib.
Hair turned white through fear and grief ib.
White triangular hairs 54
35. The heart 55
36. The pericardium 56
37. The lungs ib.
38. The thorax, intercostal muscles, diaphragm 59
39. The pleura and mediastinum ib.
40. The external parts of the middle cavity ib.
An old woman giving suck 60
41. The stomach 61
42. The intestines and mesentery ib.
43. The lacteal veins 63
44. The omentum, peritoneum, pancreas ib.
45. The liver, gall-bladder and ducts ib.
46. The spleen ib.
47. The kidneys, ureters, bladder 64
48. The hands ib.
Account of a man without arms ib.
49. The thighs, feet and legs ib.
50. The animal spirits 65
51. Secretion of the other fluids 68
52. The blood 69
53. What are the first elements of the body 70
54. Reflections 72

CHAPTER II.

OF THE NATURAL STATE OF THE HUMAN BODY.

1. What the natural state of the body means 87
2. Of the circulation of the blood ib.
3. Of respiration 90
4. Of chylification 92
5. Of nutrition ib.
Uncommon instances of the utility of abstinence 93
6. Of the senses 94
7. Of the sight ib.
8. The hearing 95
9. The smelling ib.
10. The tasting ib.
11. The feeling ib.
12. Of hunger and thirst ib.
13. Of sleep 96
14. Of local motion 98
15. Of the voluntary and involuntary motions ib.
16. Of the stature of man ib.
17. Of the age of man 100

CHAPTER III.

OF THE PRETERNATURAL STATE OF THE HUMAN BODY.

1. What the preternatural state of the body is 100
2. The variety of diseases ib.
3. Reduced to three classes; those of the solids 101
4. Those of the fluids, particularly the blood ib.
5. Those of the animal spirits 102
6. The remote causes of diseases 103
7. Of fevers ib.
8. The way to preserve health 104
9. Of life and death ib.

CHAPTER IV.

OF THE SOUL, AND OF THE ORIGIN OF MAN.

1. There is something in man, which perceives the various motions of the body 113
2. The perception is sometimes continued and recalled ib.
3. We know some things in a more sublime manner ib.
4. There is something in us which has an appetite to sensual things ib
5. And another appetite, which is often contrary to this ib.
6. How philosophers account for the direction of our bodily motions ib.

7. For the external senses 113
8. The imagination and memory 114
9. The understanding, will, and affections ib
10. This may be so, or not ib.
11. Of the immortality of the soul ib.
12. Of the union of the soul and body 114
13. Reason cannot discover the origin of man ib.
14. The scriptural account of it 115
15. Of the production of the soul ib.
Of the generation of the body ib.

PART THE SECOND.

OF BRUTES.

CHAPTER I.

OF BEASTS.

1. The general difference of men and beasts as to the structure and posture of the body 123
2. Their agreement 124
3. Their agreement and disagreement as to the head and brain ib.
4. The heart and lungs 125
5. The eyes ib.
6. The ears, nose and teeth 127
7. The windpipe 128
8. The vegetative and sensitive motions in brutes 129
9. Of the soul of brutes ib.
10. Of some particular sorts of beasts 130
Of the elephant ib.
Of the rhinoceros 133
Of the camel 134
Of the dromedary 136
Of the lamas of Peru ib.
Of the castor or beaver ib.
Of the shammoy 138
Of the roe-buck 139
Of the reindeer 140
Of the ass: its properties and utility 141
Of the mule 142
Of the zebra 143
Of the squirrel 144
Of the marmot 145
Of the hedgehog ib.
Of the pangolin 146
Of the armadillo 147
Of the animals of the monkey kind 148
Of the chimpanaze 149
Surprising assembly of monkies ib.
Of the oppossum 150
Of the ichneumon ib.
Of the jackal 151
Of the sable mice 152
Of the glutton ib.
Of the sloth 153
Of the falling off of the horns of beasts 155
11. Some general reflections 156

CHAPTER II.

OF BIRDS.

1. Some general remarks 159
2. Of their motion 163
3. Of their brain 167
4. Of their organs of sense 168
5. Of their lungs 169
6. Of their stomach and bladder 172
7. Of the generation of birds ib.
Of some particular sorts of birds 176
8. Of the largest of birds, the cuntour of Peru 179
Of the smallest, the humming-bird 180
Of Vultures: the singular service they are of in Egypt 181
Their uses in America ib.
Of rooks: their peculiar modes, or systems ib.
Of the magpie: its peculiar degrees of instinct 182
Of the woodpecker 183
Of the bird of Paradise 184
Of the American mock-bird: its uncommon properties 185
Of the crane ib.
Of the stork 186
Remarkable adventure of a tame stork at the university of Tubingen ib.
Of the pelican: its singular construction and properties ib.
Of the albatross, one of the largest and most formidable birds in America 188
Of the swan: its peculiarities and longevity ib.
Of the goose, and wild goose 189
Of the Solund goose ib.
Of a couple of remarkable eagles, and a couple of ravens, in the isle of Rona, one of the Scotch Western Isles 190
Of the down-bird in Iceland ib.
Of the bat 191
Of the kingfisher ib.
9. General reflections 192

CHAPTER III.

OF FISH.

1. The number of fish 198
2. Their covering ib.
3. Their brain 199
4. Their organs of sense ib.
5. Gills or lungs 200
6. The heart 201
7. The air-bladder ib.
8. The stomach ib.
9. The fins 202
10. Experiments on fish 203
11. Of shell-fish 205
Of the reproduction of the shells of some fish ib.
Of the extraordinary manner in which lobsters and crabs change their shells ib.
The remarkable difference of the land crabs on the Caribbee Islands 208
The surprising regularity of their descent from the mountains to the sea ib.
Of the soldier crab 209
Of crabs eyes 210
Of turbinated fish, of the snail kind 211
Of the oyster 213
The remarkable movings and operations of the scallop ib
Of the razor shell ib.
Of the multivalve shell fish ib.
Of the sea urchin 214
Of the acorn shell fish, the thumb-footed shell fish and imaginary barnacle 215
Of the murex, which gives the Tyrian purple ib.
Of pearl muscles ib.
The peculiarities of muscles in general 216
In Port Mahon harbour muscles are found in stones of immense magnitude ib.
Of the bollani, which are found to live in large stones in the Adriatic sea 217
Of other shell fish, found in Toulon harbour, and on the coast of Ancona ib
Of the pholades bollani, who buries itself in the hardest rock ib.
Of the animal flower in Barbadoes: its peculiarities as it seems an aquatic sensitive plant 218
12. Of the generation of fishes 219
The manner of sea-tortoises laying their eggs ib.
Uncommon circumstances attending the generation of soles 219
Of the coming of herrings, cod, and other fish, in shoals, at certain seasons of the year 220
Of the coming of shoals of mackerel, and the reasons for their coming ib.
Of the tunnies, which come in shoals to the coasts of Provence and Languedoc 222
Of the shoals of pilchards ib.
Of the shoals of salmon ib.
Remarkable salmon-leap near Dublin ib.
13. Of some particular sorts of fishes 223
Peculiar circumstances of the turbot ib.
Of whales ib.
Their singular manner of propagation ib.
Of the Norway whale 224
The use of blubber; their method of feeling ib.
Of the whalebone whale 226
Of the spermaceti whale ib.
The wonderful strength of the tails of whales ib.
Of the hippopotamos, or river horse 227
His uncommon depredations on land ib.
The female always brings forth on land 228
They always sleep on land 230
Of sharks ib.
Of the white shark: its amazing swiftness, and number of teeth ib.
Of tortoises 231
The great Mediterranean turtle ib.
Of the frog-fish of Surinam ib.
Of flying-fish ib.
Of the ink-fish: its singular properties ib.
Of the aborescent star-fish 233
Of the torpedo, much like a thornback ib.
Of the sea-nettle, a strange production of nature ib.
The amazing peculiarities of the limpet ib.
14. General reflections 234

CHAPTER IV.

OF REPTILES.

1. Of their motions 235
2. Of serpents 236
The astonishing number of their bones ib.
Different sorts of serpents 237
3. Of their brain, stomach, generation ib.

4. Of the venom of serpents and vipers 238
The swiftness of the poison of a rattle-snake ib.
Singular properties of the rattle-snake 239
Particular account of a person bit by a rattle-snake 241
5. Of some particular sort of reptiles 242
Of the water-snake ib.
Of the serpent of the waters ib.
Of the crocodile the king of reptiles ib.
The American crocodile, or alligator 243
Of the cameleon ib.
Four species of cameleons: the Arabian, the Egyptian, the Mexican, the European ib
The uncommon structure and motion of their eyes 244
Peculiarities of the cameleons in Smyrna ib.
Of the salamander 245
Of the oocaral of Lower Egypt, resembling a crocodile ib
Of the lizards and scorpions of Italy ib.
6. Water lizards often change their skins ib.
A particular species of water lizards, termed an aquatic salamander 246
7. Reproduction of parts cut off ib.
The remarkable reproductions of the parts of a salamander ib.
Of those of the tadpole 247
Of those of the earth-worm ib.
Of those of the aquatic boat-worm ib.
Of those of the snail 248
8. Of tape worms ib.
9. Of worms that feed on stones 249
Of the common leech ib
Of frogs changing their skins 250
The remarkable longevity of a toad 251

CHAPTER V.

OF INSECTS.

1. Of their shape and make 252
2. Of their eyes 253
3. Their heart, respiration ib
4. Their generation: particularly the silk-worm and silk-spider 254
5. Of the common spider 255
Of various species of spiders that fly 256
6. Of the tarantula, a kind of spider 257
The only remedy for the bite of the tarantula is music 258
Two relations of the extraordinary effects of music 258
7. Of the coya 259
The uncommon effects of its sting, and the only method of cure ib.
8. Of microscope animals 260
9. Of the flea 262
10. Of the louse 263
Peculiarities of lice: their amazing increase ib.
Many fishes, particularly salmon, incident to lice ib.
11. Of the death-watch 264
Remarkable circumstance of the beating of a death-watch ib.
Singular properties of the death-watch, the smallest of the beetle-kind 265
12. Of the eggs of flies 266
The eggs of insects the occasion of blights 267
13. Of gnats 268
The uncommon propagation of gnats 269
14. Of the cicadula, or cuckoo-spit ib.
The cochineal ib.
15. Of the drone-fly 270
16. Of the fire-fly of Jamaica ib.
A person may read the smallest print by the light of these insects ib.
17. Of the ephemeron, that lives but part of a day 271
Another sort of ephemeron, called the May-fly: its remarkable properties ib.
18. Of butterflies 272
19. Of caterpillars ib.
The Caterpillar of the willow 274
Peculiar circumstances in caterpillars ib.
20. Of the transformation of insects 276
That of the caterpillar very remarkable throughout its various states ib.
21. Of ants 281
The extraordinary nicety of their nests ib.
Their beautiful appearance viewed through a microscope ib.
They eat not but sleep all the winter 282
The remarkable architecture of ants ib.
The employment of working ants ib.
The red, green, and black ants of Africa 286
22. Of the ant-eater, or formicaleo ib.
His peculiar manner of ensnaring his prey, and various other extraordinary operations ib.

23. Of bees 288
The habitation of bees 289
How honey is extracted ib.
Of honey-dews 290
A kind of honey-dew produced by a small insect called the vine-fretter ib.
Ants as fond of this as bees ib.
The curiosity of the sting of a bee, or wasp 291
The peculiar privileges attendant on, and homage paid to the queen bee ib.
The swarming of bees 293
24. Of the polypus 295
Of various corallines, a species of polypi ib
The polypus, an aquatic animal, found in ditch-water 297
Experiments on a polypus ib.
Clustering polypi more strange than the rest 298
The nature of corallines, and the mechanism of their polypi 299
The polypus is an animal of the vermicular kind 300
25. Of the transformation of animals 301
Quadrupeds undergo a yearly change 302
Viviparous animals have a more sudden change ib.
The transformation of oviparous animals ib.
The transformation of tadpoles ib.
That of the beetle class, particularly the cock-chaffer 302

CHAPTER VI.

GENERAL OBSERVATIONS AND REFLECTIONS.

1. Of the number of animals, the various species of beasts, birds, fishes, and insects 303
2. The Creator uses divers means for the same end 304
Of the different methods of taking their food ib.
3. That brutes are not mere machines 305
4. Of the natural instinct of all creatures 306
5. Of the clothing of various animals 307
6. Of the admirable sagacity of animals in the structure of their habitations 308
7. Of the peculiar care of Providence over all his works 309
8. The remarkable destruction and reparation of the whole animal creation ib.
9. Farther reflections on the world in general 310
10. A comparative view of the animal world, extracted from Mr. Hervey 313

PART THE THIRD.

CHAPTER I.

OF PLANTS.

1. What we mean by plants 319
2. Their liquid parts ib.
3. Their solid parts ib.
4. Of the bark ib.
5. The wood 320
6. The pith 321
7. The roots and branches ib.
8. The leaves ib.
9. The nutrition of plants 322
10. Water not the nutriment of plants ib.
11. The motion of the nutritive juice 325
12. The descent and ascent of the sap ib.
13. Of the increase of grains and seeds 326
14. Of male and female plants 327
15. Of the sleep of plants 328
16. Of the agreement between plants and animals 331
17. Of the generation of plants 335
18. Of their flowers 335
19. Of their seeds 337
20. Of their fruits 342
21. Of the perspiration of plants 343
22. Trees inverted will grow 346
23. Of the propagation of several plants ib.
24. Of grain planted in various substances 348

CHAPTER II.

1. Of some particular plants 350
The submarine grass ib.
The vines of hops ib.
The herb of Paraguay, or caa-tree, a species of tea 351
The coco-tree ib.
The cacao-tree 352
The tallow-tree; the horse-chesnut ib.
The sago-tree ib.
Palm-tree; they are male and female ib.

Sicilian plants; particularly cinnamon, sarsaparilla, sassafras, and rhubarb 353
The balsam-tree ib.
The flowering-ash, whence manna is produced ib.
The Peruvian bark-tree 354
The cotton-tree, the pepper-shrub ib.
The plant which affords ginger ib.
Of the produce of nutmegs 355
The wild pine ib.
The water-withy of Jamaica ib.
The fountain-tree of Hierro, one of the Canary Islands ib.
The manchineel-apple: its poisonous qualities 356
Remarkable method of poisoning by the negroes in Africa 357
Of a plant like doronicum, wherein quicksilver is found ib.
Of the aloe; its singular properties ib.
The cereus, or the prickly pear of America 359
Peculiarities in the production of mushrooms 360
Of sea plants: the coral in particular 361
2. Sugar not unwholesome ib.
3. Of maple sugar ib.
4. Molasses made of apples ib.
5. Ambergris 362
6. Of the corruptions of plants and animals ib.
7. General reflections 367
8. Essay on the production, nourishment, and operation of plants and animals 376
Sect. 1. Creatures produce their own kind ib.
Sect. 2. The laws of nature sufficient for the production of animals and vegetables 379
Sect. 3. Of the nourishment and growth of plants 380
Sect. 4. Of the nourishment and growth of animals 383
Sect. 5. The similar operations of plants and animals 385

CHAPTER III.

OF METALS, MINERALS, AND OTHER FOSSILS.

1. The variety of fossils 391
2. The general properties of metals ib.
3. Of the nutrition and generation of metals 392
4. Of gold, silver, platina, copper, iron, tin, lead 393
The chief properties of gold ib.
The malleableness or ductibility of gold beyond all imagination 394
Silver comes the nearest to gold in ductility and resisting fire ib.
Of platina, an original metal between gold and silver, discovered in New Spain 395
It is extremely hard to melt 396
It comes nearest to gold in weight of all other metals ib.
Copper is next to silver in ductility 397
How brass is made ib.
Of iron ib.
The arbor martis, a germination of iron, resembles a natural plant 398
Various experiments ib
5. Of steel 399
6. Of quicksilver: its singular properties ib.
Copper and iron, gold and copper, silver and lead, tin and lead, frequently found in one mass 400
7. Of mines in general 401
8. Of mundic ib.
9. Of the fissures of the earth 402
10. Of salts 404
Remarkable salt-mines in Poland ib.
11 Of stones ib.
12. Of petrifying springs 406
13. Of copper springs 407
14. Of lime 410
15. Of precious stones ib.
16. Of the loadstone 412
17. Of inflammable fossils 415
18. Of amber 416
19. Of linum asbestum ib.

PART THE FOURTH.

OF EARTH, WATER, FIRE, AIR AND METEORS.

CHAPTER I.

OF EARTH AND WATER.

1. Of the formation of the earth 419
Of the earth's movement ib.
2. Sand probably the earth's general cover 421
3. An inundation of sand ib.
4. Of mountains 422
5. The benefit of mountains 423
6. The height of mountains ib.
Particular height of several mountains in France ib.
That of Mount Atlas 424
Of the formation of mountains after the flood 426

Of the formation of an iron mountain in Sweden 428
7. Of water 429
The chief properties of water 431
8. Of ice 432
Rivers always freeze first at the bottom ib.
Standing waters freeze first at the top ib.
Surprising effects of severe frosts on trees and other vegetables 433
The amazing bodies of ice near Hudson's Bay 435
Some waters in Scotland which never freeze ib.
9. Of fountains 436
Curious experiments, shewing, that vapours from the sea supply all fountains and rivers 437
10. Of the sea 438
11. Of rivers and islands 440
Of the great rivers in Africa ib.
Description of the river Nile 441
Peculiarities of the Thames water ib.
Of the cataract of Niagara 442
American rivers the largest in the world ib.
The amazing length of the course of the Rhine 443
Of various fresh and salt water lakes ib.
Of the formation of the main islands of the globe at the deluge 445
12. Of the basin of the sea ib
Of the little difference there is between the bottom of the Adriatic sea and the neighbouring countries 447
The greatest and ordinary depths of the sea 448
13. Of the tides 450
14. Of currents in the sea 453
Methods of making sea water fresh 455
Method of keeping fresh water sweet 456
Sketch of Mr. Hervey's reflections on what is observable in the terraqueous globe ib.
Curious remark of Dr. Cheyne concerning fluids in general 465
Of the islands of Scilly, so noted among the ancients 467
15. Of subterraneous trees 470
Subterraneous trees in Italy 471
Subterraneous trees in Ireland 473
16. Of the origin of bogs 474
Of several bogs in Ireland ib.
Of some large ones in England 475
A remarkable one in Scotland 477
General remarks on our globe 479